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ART. L.—*On some points in Mallet's Theory of Vulcanicity;* by EUG. W. HILGARD, Univ. of Michigan.

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THE main points of Mallet's Theory of Vulcanicity have been before the world of science for some time, and have excited some lively discussions on both sides of the question; mainly in the English press. I think it is to be greatly regretted that the original memoir, very tardily published in the Transactions of the Royal Society, should be so difficult of access, that few of those interested are enabled to appreciate the caution and laborious conscientiousness which Mallet has brought to bear on his investigation and discussion of this most complex problem; and to what extent he has himself anticipated most of the objections raised. In calling attention to some apparent omissions in this respect, it may be useful to recall the state of the question as regards some of the more prominent points at issue.

The first and most sweeping attack upon the very basis of Mallet's theory comes from Sir Wm. Thomson, in a letter to Mr. Poulett Scrope (Nature, Feb. 1, 1872), in which he calls attention to, and re-affirms, the results of his investigation (supplementary to that of Hopkins) on the effect which a fluid nucleus and imperfect rigidity of the earth must exert upon precession and nutation; and which led him to the conclusion that, unless the rigidity of the globe as a whole were greater than that of steel, there must ensue a tidal deformation of the solid mass, which would sensibly change the amount of preces-

sion. He denies that Delaunay has shaken, in any important point, the conclusions of Hopkins or himself.

The subject has since been taken up by Gen. Barnard (Smiths. Contr., No. 240), who, while confirming the results of Thomson upon the premises assumed by that physicist, also shows that there are assumable and admissible conditions upon which a fluid nucleus with a moderately thick crust may exhibit the same constant, or periodically recurrent, amounts of precession and nutation, as a solid globe.

Mallet refers to Thomson's argument in favor of great rigidity as corroborative of the necessity for assuming a crust of great thickness, such as would render it inadmissible to assume a direct connection between volcanoes and the liquid nucleus. But it is difficult to see how the "preternatural rigidity," made a postulate by Thomson, could in any manner be compatible with the requirements of Mallet's theory. For the latter represents the earth's crust as a congeries of fragments, sustained partly by the contracting liquid nucleus, partly by each other on the principle of the arch; therefore necessarily often locally in a state of unstable equilibrium, and liable to be disturbed by slight outside forces. That the tendency to tidal deformation contributes toward producing such disturbances has been rendered probable by Perrey's discussions, and by the repeated coincidences of violent earthquakes with tidal extremes, lately observed.

Thomson's assumption, that the postulated rigidity might result from compression, would scarcely seem admissible save in a case of *absolute* homogeneity and equilibrium—if then. It is certainly incompatible with the demonstration made by Prof. Belli of Pavia (as quoted by Mallet), to the effect that rigid bodies are weakened by the simultaneous application of orthogonal pressures; that no known materials could sustain, under any circumstances, a strain several hundred times greater than that which would crush it if laterally free to yield. That such strains exist in the contracting crust, and that upward deformation must result, if such contraction takes place at all—as the annual loss of heat by the earth compels us to assume is the case.

Whether we view the question of rigidity by the light of our direct knowledge of the first twenty-five miles of crust, and of the profound commotions it experiences from time to time; or by that of the demonstrated increase of temperature as we descend, rendering it extremely probable that at a comparatively slight depth the rigidity of all materials must be seriously impaired by a high temperature, despite of pressure; or whether we even consider alone the secular loss of heat by radiation, which must result in a contraction affecting un-

equally the heterogeneous *couches* of which, on any hypothesis, the solid portion of the earth must be composed; it will be difficult to persuade geologists of the actual existence of the "preternatural rigidity," until every reasonable hypothesis that can dispense with this assumption shall have been exhausted.

Among the objections raised by geologists, the first and apparently gravest was that of Forbes (Nature, Feb. 6, 1872), who argues the untenableness of Mallet's theory on the ground of the asserted general identity of composition of volcanic ejecta. In fact, from Mallet's point of view it would seem, that lavas might have the composition of any fusible rock whatsoever, in whose strata the crushing might happen to occur; and hence that, if taking place within the sedimentary strata, there ought to be a very great diversity between the ejecta of different vents.

In his rejoinder, Mallet calls attention to the very serious differences of composition between the extremes of trachytic and basaltic lavas, and to the generally admitted fact that volcanoes are located along axes of upheaval, where the hypogene rocks, and therefore those of the crust proper, approach the surface; hence that crushing along these lines of weakness would be by no means likely to produce a greater diversity of lavas than we actually observe. Furthermore, that the "local lake" theory is liable to the same objection, unless the lakes are supposed to be located within the (uniform) crust itself.

He might, it seems to me, have added that the maximum of twenty-five miles of sedimentary rocks is not anywhere (on the continental areas at least) actually superimposed, vertically, upon the crust; and hence that it is not unreasonable to assume that a pressure sufficiently great to produce fusion may never occur within the limits of the sedimentary strata, albeit other manifestations of subterraneous thermal action may not be wanting. It is true that, on the whole, Mallet's memoir leaves upon the reader's mind the impression that he seeks the source of volcanic action at depths sufficiently shallow to justify in a measure the objection raised by Forbes; although he expressly declares that with our present data, the determination of the points at which the maximum of crushing effects occurs is impossible.

Similar considerations apply to the objection raised by F. W. Hutton (Nature, Nov. 27, 1873), that "faults show no heating effects, even where considerable crushing has taken place." The pressure under which the faulting occurred may have been inadequate, in the cases coming under our observation; but above all, *time* is a most essential element in this connection. No matter how great the dislocation or crushing, no great increase of *temperature* can occur if it takes place *slowly*,

however great may be the *quantity* of work performed, or of heat produced. And very many, if not the majority of extensive faults actually occurring, show evidence of having been formed without cataclysmal disturbance.

Among the other points raised by Hutton (*loc. cit.*) there are several which are at once disposed of by a perusal of the original memoir. There are others of some weight. That "lines of least resistance once chosen must remain," is doubtless true in a very wide sense; and in that sense this is scarcely at variance with observed facts, since the lines of weakness along the borders of continents are still those which exhibit volcanic activity (and earthquake phenomena) most frequently. But, in the folding and upheaving of strata by tangential thrust, the question of equilibrium must often of necessity be very delicately balanced; depending as it does upon the vertical pressure of the masses, their nature, dislocation, subsequent consolidation, igneous effusions from fissures, etc. Lines of weakness as to *rigidity* may thus easily acquire sufficient *static* resistance to cause a subsequent yielding to take place at some distance from the original axis; as is exemplified in the formation of successive parallel ranges. What is true with regard to the formation of folds, is equally so as concerns the settling down of the crust-fragments in consequence of interior contraction. Each fragment as a whole may remain as such, being only as it were abraded at its circumference. But it is only necessary to have observed the gradual yielding of detrital rock masses under pressure, to understand why the cataclysmal yielding which manifests itself in earthquakes should so frequently change its locality of occurrence; why for long periods a region may be completely exempt from these movements, in consequence either of an unresisted and therefore gradual descent of the crust fragments underlying it, or of an arch-like arrangement, whose sudden breaking down will result in a catastrophe, succeeded perhaps by a long period of quiescence.

Thus, Mallet's theory accounts equally well for the sporadic and apparently lawless occurrence of seismic phenomena, and for the probable correlation between the frequency and violence of earthquakes, and tidal extremes. Unlike the theory of a thin crust, which would lead us to expect almost diurnal earthquakes corresponding to oceanic tides, according to Mallet's view, there should be a near coincidence in time and space of two independent factors (viz: of a condition of very unstable equilibrium of some crust fragment, with a tidal extreme), in order to produce a maximum of disturbance. It cannot be expected that such coincidence should be of frequent occurrence, or that the casual connection should manifest itself in a greater predominance than that claimed by Perrey for the

times of spring and neap tides. Mallet does not, however, allude to this point; whether from a distrust of Perrey's data and method, or theoretical scruples on the score of "rigidity."

The objection that, according to Mallet's theory, earthquakes ought always to be followed by eruptions, could obviously apply only during the period of fissure eruptions from the liquid interior; it being conceded that the volcanic eruptions of to-day are due to contact of water with the molten rock, and that steam, not static pressure, is the *vis-a-tergo*. It is, of course, very probable that the access of water to the volcanic focus* is generally caused, or facilitated, by such crust movements as would at the same time result in the production of more heat, and perhaps of fused rock; such movements being indicated by the (mostly slight) earthquakes that so frequently precede a period of volcanic activity. Hutton's objection, that according to Mallet's view each eruption ought to be preceded by a sensible subsidence, is therefore groundless.

One point, however, must strike every reader of the original memoir, viz: the pre-eminence given by Mallet to the *crushing of solid rock* as the means of producing heat and fusion. One would naturally look to the results of his experiments on this subject for the proof of the efficiency of this agency. But we find that the maximum of *temperature* resulting from the crushing to powder† of the hardest rock, is something over 217° Fahr. This, then, represents the maximum increment of temperature that can be rendered efficient toward the fusing of rocks by the crushing process, under the most favorable circumstances, viz: upon the supposition that it takes place instantaneously, or under such circumstances that the heat cannot be conducted away; and farther, that the resistance of the rock has not been materially diminished by the downward increase of hypogeal temperature. At the most moderate depths at which volcanic phenomena can be supposed to originate, the last mentioned factor must exert a very considerable influence, reducing materially the available heat-increment. Hence the numerical results of Mallet's laborious experiments on rock-crushing, however interesting and useful as affording a definite measure of the thermal effects producible by this means, yet fail to carry conviction as to the efficacy of this particular *modus operandi* in reducing large masses of solid rock to fusion —unless essentially supplemented by *friction;* not so much of

* Hutton (*loc. cit.*) avers that "to cause a volcano the heat must go to the water —the water cannot go to the heat;" but omits any explanation of this singular axiom.

† Mallet does not go into the consideration of the physical nature of this "powder," and of the thermal and other differences likely to result from its production under pressures enormously greater than those employed by him.

rock walls against each other, but more probably by the heat produced within more or less comminuted *detrital*, or *igneo-plastic* masses, by violent pressure and deformation.

It may be doubtful what would be the physical and thermal effect of enormously great pressures upon rock powder such as was produced in Mallet's experiments; but it would seem that if *made* to yield, the frictional effect must produce very high temperatures. *A fortiori*, solid detrital masses of variously sized fragments intermingled (such as, rather than powder, would be likely to result from steady pressure), yielding rapidly under great pressures, might, under the *combined influence of friction and rock crushing*, well be supposed to reach the temperature of fusion, which a simple crushing of a solid mass by pressure would have failed to produce. Mallet mentions the probable influence of friction, and of the squeezing of igneo-plastic masses; but does not attach to these agencies such importance as they seem to me to deserve.

Of the complex thermal effects of the movements of detrital masses under great pressure, Mallet's figures of course offer no measure whatsoever; nor is this, or even the thermal co-efficients resulting from his rock-crushing experiments, at all necessary to the establishment of the postulates of his theory.

Taking for granted the correctness of Hirn's theorem, "that the heat evolved in the crushing of rigid bodies is the equivalent of the work performed," Mallet's experiments on the contraction of fused rock in cooling, and his estimates of the amount of volcanic energy manifested on the globe, coupled with that of the earth's annual loss of heat, completed the proof of the *quantitative* adequacy of the cause invoked by him. And when it is understood that the earth's present loss of heat during sixteen and a half years is the mechanical equivalent of all the volcanic work performed since the period of fissure eruptions, the burden of proof of the *qualitative* inefficiency of the several modes of action that may come into play, would seem to be effectually thrown upon the opponents of the theory.

Among these modes of action, the fusion of masses already existing in a pasty, or generally more or less igneo-plastic condition, by squeezing or forcible displacement, seems to me to deserve especial attention. At the depth at which volcanic phenomena must be supposed to originate, this condition must be closely approached; especially in the early times of the volcanic period—that of the "Maare" of the Eifel, and other similar cases representing the transition phase between the régime of fissure eruptions and that of volcanoes proper. In this period of a "greatly stiffened and thickened crust," even slight flexures, whether synclinal or anticlinal, would occasion great displacements and movements in the half-stiffened upper layers

of the "viscous *couche;*" and if these experienced local refusion, the fused matter may well be presumed to have often been disposed of by eruption through fissures or volcanic vents, rather than by overcoming, downward, the inertia of the viscous *couches.* This mode of action seems to me likely not only to afford a more copious, but also a more constant or lasting source of supply, than the supposed crushing of solid rock, and appears especially applicable to the case of large fissure eruptions.

Among the greatest services rendered by Mallet's (or, in this connection, Wurtz') theory, is the unstrained explanation of many of the phenomena of metamorphism, that were quite unintelligible so long as the heat required for the observed changes was supposed to be derived from below, and perhaps by transmission through strata which themselves had experienced little or no change of condition. The principle that the heat evolved in the flexure or forcible compression of strata is, *cæteris paribus*, proportional to the resistance offered by them to the external force, throws a flood of light upon numerous apparently contradictory phenomena, which have long been quoted as incompatible with the doctrine of metamorphism as held in this country, and have stood in the way of its general acceptance by geologists, particularly on the continent of Europe. In its application to the formation of synclinoria especially, the principle works most instructively and satisfactorily. It can scarcely be doubted that in the first folding of the vertex of a geosynclinal, weakened below by fusing away and heating of the crust and lowest strata, the movements were comparatively localized and rapid, and therefore capable of producing high temperatures, and their results such as we now usually find them along the main axes of elevation of synclinoria. But as the resistance along this axis increased by emergence and solidification, the points of yielding, i. e., the folds, would be *multiplied*, while the absolute amount of motion transformable into heat would be *diminished* in each. Hence the decrease, *in general*, of metamorphic effects, as we recede from the main axis. And yet it is perfectly easy to conceive of large local exceptions to the general rule (such as we actually observe), on the basis of greater resistance in perhaps a localized stratum of a lateral fold, yet so situated that it could not successfully resist the influence of an advantage of leverage causing a rapid deformation. It is even predicable that under such circumstances, sudden breaks and crushings must occasionally have occurred, giving rise to fusion of rocks and limited fissure eruptions; or, at the least, to pasty rock intrusions, as suggested by Dana, for granitic and analogous veins, that show no evidences of the co-operation of very high temperature in the act of formation.

LeConte's view, that the first mashing of a geosynclinal would produce *less* heat than later plications,* in which (presumably) a greater resistance would have to be overcome, seems hardly to be compatible with facts as generally observed, away from the Pacific coast eruptions; and his argument is the less cogent, as the temperature produced is a function, not only of the resistance of the rocks, but also of the *degree* and *rapidity* of the motions, both of which have been on the decrease in late geological periods, in accordance with the diminishing rate of contraction of the earth and the increased resistance of the crust to flexure.

While Mallet's theory accounts satisfactorily for earthquake phenomena and volcanic activity as manifested since the cessation of fissure eruptions: and also for the gradual or sudden *depression* of both large and small areas, even subsequent to that time; it makes no provision for their *elevation*, and therefore leaves unexplained the numerous *oscillations* of level of which we find the record, down to our own time. In assuming the movements as taking place exclusively within the solid shell, he (unnecessarily as it seems to me) leaves a point open to objection.

While admitting that slow secular oscillations, or those minor changes of level constantly occurring in volcanic areas, may even now in many cases be reasonably attributed to changes of temperature occurring within the solid rocks themselves, and within their limits of elasticity: it is impossible to assign this as an adequate cause of those extensive oscillations which have characterized the Quaternary period, and are recorded, e. g., by the raised beaches of the North Atlantic coasts and inlets; and by the drift pebbles even now found four hundred and fifty feet below the level of the Gulf of Mexico, while the emerged formations record a complementary elevation to at least a similar extent during the Terrace epoch. This record of an oscillation of near a thousand feet on the Gulf shore since the glacial drift epoch, implies *at least* a corresponding one over the greater portion of the area drained by the Mississippi, unless that river flowed backward at one time.† Doubtless

* On the great Lava-flood of the West. This Journ., March, 1874, p. 179.

† It is a curious fact that in the various hypotheses regarding the oscillations of the continental interior during the Drift epoch, the facts observed on the Gulf shore have over and again been quietly ignored; although the Gulf is unequivocally the natural reference level most directly related to that interior, not only at the present time, but as the direction of the Drift currents and the trend of the formations show, ever since the time of the Cretaceous emergence. Nevertheless, the reference level has been sought beyond the Allegheny upheavals, or beyond the fixed Azoic area upon which the movement appears, in a measure, to have pivoted, and where, as Dana has shown, it was materially diminished in extent. Assuredly, no hypothesis which disregards the changes of level registered at the continental outlet, has any *raison d'être!*

these oscillations, like the glaciation of which they probably were coöperative causes, were of continental extent, as was the (more or less contemporary) emergence of the Siberian plain; and as such, they must be presumed to have been true movements of the earth's crust, although lying quite within the volcanic period proper. It is but reasonable to suppose that the sinking of the great Pacific area was then, and may still be, of a similar nature.

If Mallet's theory, as well as the geological facts with which it deals, is incompatible with Hopkins' and Thomson's postulate of extreme rigidity; if, as it appears to me, the events of very recent geological epochs, in connection with the very slow rate of cooling since that time, render it unlikely that the crust can even now be considered as rigid in a geological sense; if finally, as Gen. Barnard affirms, the astronomical objection to a comparatively pliant crust and liquid nucleus is not absolute, but may be obviated by admissible assumptions regarding the mode of distribution of the solid and liquid matter constituting the globe: we are led to the reasonable assumption that, while the thickness and rigidity of the crust is evidently too great to admit of farther folding, or fissure eruptions, and (probably) to admit of connecting ordinary volcanic phenomena directly with the (virtually or actually) liquid interior, yet we need not assume it to be so great as to render the crust incapable of yielding somewhat, *on a large scale*, to static upward pressure. Such pressure may be either the resultant of tangential stress, such as might slightly deform an arch without fracture or folding; or even the direct result of a corresponding subsidence elsewhere.

The latter effect would of course be incompatible with a shrinking away of the fluid interior from the crust, as required by Mallet's theory, if it were necessary to assume that the interior crust-surface is substantially "smooth," i. e, free from important downward projections or upward sinuosities. But so far from this, the cooling influence that has so long acted on the oceanic areas, contrasted with those enormous outwellings of igneous rock that have occurred even in late Tertiary, or Post-Tertiary times, together with other considerations, necessitate the assumption that such inequalities do exist to a notable extent. Hence the overlapping alluded to by Mallet, of the period of fissure eruptions and of that of volcanic activity proper, which appear to have coëxisted, in *different* portions of the globe, from early Tertiary to early Quaternary times. For even Mallet himself considers the outpourings of igneous rocks on the Pacific coast as "wholly inconsistent with existing volcanic forces," and few geologists will agree with LeConte * in

* This Journal, March, 1874, p. 170.

ascribing precisely these most extensive fissure eruptions in the world to the "ineffectual fires" of the volcanic period, arising alone from transformed motion.

Indeed, it is not easy to understand the precise mechanism of the great fissure eruptions as a consequence of nucleal contraction, without the aid of some static head of pressure that may exist more or less locally, in consequence of inequalities in the crust (whether of form, thickness or density), and thus act as a *vis-a-tergo*.

At first blush, the "squeezing out of sub-mountain liquid matter," assumed by LeConte as the consequence of the folding and fissuring of strata by tangential thrust, appears natural enough. Yet it seems hardly possible that the same force which makes and *elevates* mountain folds (being the *result of interior shrinkage*) should at the same time serve to *compress the interior liquid;* unless either such folding occurs beneath the general level of the liquid; or the latter is locally confined; or the movement is so (comparatively) brusque or cataclysmal, that viscosity would prevent the lateral or downward escape of the liquid rock. In the case of the Pacific eruptions, the evidence of steady static outflow, and regular upbuilding, is especially cogent; and as LeConte remarks, it has been slow work —as, indeed, is usually or universally the case with mountain building.*

The assumption of locally limited fire seas with a solid globe, as made by Dana† in conformity with Hopkins's views, would remove the difficulty, if the crust could be assumed as contracting, on the whole, independently of the portions over fire seas. But when we come to discuss the application in detail of this intrinsically improbable hypothesis, we find the required extent and localities of these fire seas to be such, that we can hardly imagine them to be effectually separated from each other; in other words, we approach very near to a condition of general under-crust fluidity, up to late geological periods.‡ It then becomes a question of minor importance, whether there is a central nucleus solidified by pressure, or whether all within the crust is actually liquid.

* When LeConte says (loc. cit., p. 179) that the outsqueezing of the liquid has been caused by "enormous horizontal pressure, determined by the interior contraction of the *whole* earth;" and then (p. 180) that "whether by uplifting or upbuilding, the actual increase of height would be precisely the same, being determined by the amount of lateral crushing," he seems to think of crust-contraction upon a nucleus *too large* for it, rather than of Mallet's "freely descending" crust. Or, if he considers the fused rock as the result of motion transformed, it is difficult to see on what ground a simple "*uplifting*" could be considered the precise mechanical equivalent of an *upbuilding* by eruption of liquid rock. In either case the *lifting* done would be the same; but what of the enormous *heat of fusion*?

† On some of the Results of the Earth's Contraction, this Jour., Aug., 1873, p. 105.

‡ Ibid., July, 1873, p. 7 and ff.

The inherent improbability of the depression of a geosynclinal trough to a level so low as to allow the liquid rock to *rise into it*, as it were, is too great to render its discussion necessary.

Indeed, it seems almost impossible to imagine a mechanism explaining satisfactorily fissure eruptions such as those of the Pacific coast, on the basis of a slowly contracting *solid* crust with a rapidly contracting *liquid* layer or nucleus beneath. A more satisfactory explanation seems possible, if in accordance with Mallet's suggestion, and the intrinsic probabilities of the case, we assume the existence of a thickly viscid, igneo-plastic under crust layer. Such a layer, while barely, or very slowly, obeying the laws of liquid equilibrium, would be capable of being liquified by a slight increase of temperature, such as might be produced by squeezing or kneading. Portions of such plastic matter would occasionally become involved in the anticlinal folds of synclinoria, and thus supply the material for limited fissure eruptions, in that case literally "squeezed out." But the inverse ratio pointed out by Dana as existing between folding and fissure eruptions, points to the rarity of such events.

At any rate, they could not explain the outwellings of the Pacific border, which continued long after close plications had ceased to be made; in fact, as it would seem, up to the end of the period of elevation of the main Sierra Nevada.

It is but fair to assume that near lines of weakness indicated by plications or fissure eruptions, the isogeotherms *have been* during the elevation of mountain chains (and probably still *are* where such lines are marked by volcanic vents) considerably above their general level. In an anticlinal upheaval, they would probably conform to the progress of the sublevatory movement, in a ratio more or less directly proportional to the rapidity of the upward movement; and would gradually descend during periods of repose. This would happen independently of any heat generated by transformation of motion.

In a polygenetic chain like the Sierra Nevada, after the collapse and folding of the geosynclinal and the subsequent stiffening of the backbone (so to speak), any further elevation of the *main ridge* becomes a *quasi* anticlinal movement, accompanied necessarily by the compression and "squeezing" of the heated rocks embraced within the arch. The heating being greatest, *cæteris paribus*, where the resistance and motion is a maximum, more heat would be generated by the compression of the upper, half-stiffened portion of the viscous or igneo-plastic layer, than in the lower ones; and the liquid matter so formed would constitute a head of pressure, from which fissure eruptions might derive their material; whether directly, or by pressure communicated to more distant points of rupture and fusion by lateral stress.

If then, as LeConte's data seem to show, the final and most considerable anticlinal elevation of the great interior range took place during the same period that witnessed the great fisssure eruptions of the Coast and Cascade ranges, it may not be unreasonable to suppose these events to have not only been contemporaneous, but to have borne to each other something of the relation of cause and effect; and that each of the numerous superimposed strata of igneous rock in the latter region may represent, not only the direct effect *in loco* of more or less paroxysmal thrusts, but also the reflex action of the simultaneously progressing anticlinals in the high Sierras.

ART. LI.—*On the Age of the Lignitic formations of the Rocky Mountains;* by L. LESQUEREUX.

PROF. J. S. Newberry has published, in a former number of this Journal (*On the Lignites and Plant-Beds of Western America*), some remarks bearing directly on my views of the Eocene age of the Lower Lignitic formation. As the data from which my conclusions have been derived are therein incorrectly represented, I find it necessary to state the case as it is, merely considering, in this answer, the advantage of science, in order that subsequent researches in our American vegetable paleontology may not be encumbered by misunderstandings.

I will successively answer the propositions of Dr. Newberry, which are presented as follows:

1*st. The flora of the Colorado Lignite-beds has almost nothing in common with that of the European Eocene. Its botanical aspect is certainly entirely different, and, in my judgment, not a single species and scarcely any genera are found in both.*"* In confirmation of this statement and to prove the assertion *that* "*in a botanical point of view he is quite safe in the statement that the Eocene flora has not yet been recognized in this country,* he adds: *that the Eocene flora, as exhibited in the Island of Sheppey, at Mt. Bolca,* etc.,† *has a distinctly tropical and Indo-Australian character.*

This last statement, literally translated from Prof. Heer (Flor. Tert. Helvet., iii, p. 314), forces me to consider the matter with somewhat more detail than I should have done if I had been limited to the examination of facts concerning our American paleontology only. And I am the more disposed to meet the objection, because I have already exchanged some remarks on this subject with Prof. Heer.

The flora of Sheppey cannot be taken into account for a comparison with the fossil plants of our Lignitic, mostly repre-

* Loc cit., p. 400. † Loc cit., p. 402.

sented by leaves, for the good reason that this flora of Sheppey or of the London clays has furnished to the researches and to the examination of Bowerbank a large number of fruits—nuts and seeds, of various and uncertain affinity—and nothing more. They are literally heaped in the clay, without any trace of leaves or of other vegetable organs. Fruits of this kind have not been found elsewhere in the Tertiary strata of Europe, except a few mentioned, and not yet described, from Mt. Bolca, by Massalongo, and two *Nipadites* (the genus which more than any other represents an Indo-Australian type), in the Miocene of the Bouches du Rhone, France. These Sheppey fruits, as Heer remarks, are not characteristic of the formation, and do not even furnish any evidence on the climate of the locality where they are found, as they may have been floated from great distances and are analogous to existing deposits of this kind at the mouth of the Ganges. The flora of the Island of Wight, at Alum Bay, recognized as Eocene, has furnished leaves of *Azalia*, *Daphnogene*, *Ficus*, *Zizyphus*, *Cæsalpinia*, which, according to Heer, have such a marked tropical and subtropical character that the fruits of Sheppey may have been derived from the plants of this region. These leaves, to quote the same authority, are very similar to species of Mt. Bolca; *three species* are identified as the same, and, too, a number of them are Miocene, as *Quercus Lonchitis* Ung., *Laurus primigenia* Ung., *Myrica* (*Dryandra*) *acutiloba* Brgt., *Cassia phaseolites* Ung., and other species of *Laurus*, together with species of *Quercus* and *Juglans*. As no description has as yet been given by Massalongo of the species of the Eocene of Mount Bolca, from which Heer derived his statement in regard to its character, we have no data for comparison. In his table of the families of plants which Massalongo has observed in the Mt. Bolca flora, Heer mentions as more numerously represented 48 species of *Algæ*, 5 *Podocarpi*, 7 *Palms*, 5 *Proteaceæ*, 10 *Ericaceæ*, 10 *Sterculiæ*, 15 *Leguminosæ*, etc. Neither in this, nor in the comparison of species made above, can I find a more marked Indian and Australian type than is indicated by what I consider as our Eocene flora. But, further, the genera named from Alum Bay, *Daphnogene*, *Ficus*, *Laurus*, *Quercus*, *Myrica*, are all represented in our Lower Lignitic flora; and of species positively identical with those of Alum Bay, we have *Laurus primigenia* and *Quercus furcinervis*, this last from Black Butte, also sent by Prof. Jos. LeConte in numerous and very fine specimens from Tertiary strata overlaid by lava beds, in Oregon, together with leaves of *Podocarpus*, also a European Eocene genus. And as very closely allied to, if not identical with Alum Bay and Mt. Bolca species,* we have a *Daphnogene* from Golden, and a

* Neither the species of Alumbay nor those of Mt. Bolca have been described; a close comparison is therefore not possible.

Myrica from Black Butte; these, with a number of species of Palm and of Fucoids. So much for the assertion that *not one of the species, not even a genus of the Eocene of Alum Bay and Mt. Bolca, are represented in our Eocene flora.*

But this question has to be considered from another point of view. Prof. Heer has included nearly the whole Tertiary flora of Europe in a single division of the Tertiary, the Miocene, referring to it the Sotska, the Mt. Promina, the Bornstædt, the Mt Vegrone floras, etc., which he places in the Tongrian or Lower Miocene. Except perhaps for the flora of Sotska, the European paleontologists have not admitted this division. Neither Ettinghausen, nor Saporta, nor Schimper have taken it into account in their works. Even Prof. Heer, in his introduction to the flora of Bornstædt, is undecided as to its reference to the Eocene or the Miocene. Now it is especially to the Upper Eocene flora of Europe, as known from Mt. Promina, Bornstædt, the lower gypsum beds of Aix, the old Travertines of Sezane, these last positively referred to the Eocene by Saporta, that our Lower Lignitic flora is related; not only by most of its genera but by positively identified species. With the Promina flora we have as identical *Sphenopteris eocenica, Goniopteris polypodioides, Flabellaria latania* and apparently *Paliurus zizyphoides;* and also from Golden this year two species of *Nelumbium*, one of which is closely allied to *N. Buchii* of the same Promina flora; with that of Bornstædt, a *Pteris* and a *Diplazium*, intimately related to *Pteris Parschlugiana* and *Diplazium Mülleri; Quercus angustiloba* A. Br., which Mr. Meek and myself found, in fine specimens, in the hard white sandstone overlying the lowest coal bed of Golden, at a short distance above the Cretaceous clay-beds, with *Flabellaria Zinkeni, Diospyros brachysepala* and *Juglans Ungeri.**

To this positive evidence by identity of species we have the general Eocene facies of Europe represented in the Lower Lignitic flora by the great abundance of *Sabal* leaves and palm fruits in all the localities where fossil plants have been found, from Placiére Mountain, New Mexico, to Rock Spring, Wyoming. At some places, as at Black Butte, Golden, Colorado Spring and the Raton, the palms seem to have composed one-half of the whole vegetation. At Golden, Sabal leaves have been found of enormous size, the petioles of some of them measuring three inches across and two inches on each of the sides. In the coal also are found large carbonized trunks of palms, whose texture is perfectly preserved; and all around in the hills the ground is strewn with fragments of silicified wood of the same kind of plants. In Europe, all the

* This last species is not positively ascertained, the specimens of the past year's collection being now under examination.

Sabals as yet described, eight species, belong to the Eocene, three only ascending to the Miocene. With this, the lower Lignitic flora has a predominance of fucoids, already remarked, and of subtropical and tropical types, not seen in any other stage of our Tertiary, and still less in the Cretaceous floras; large leaves of *Ficus* of the palmate-nerved section; of *Cinnamomum*, *Dombeyopsis*, etc.; the large *Platanus Haydenii* and *Pl. Raynoldsii*, both abundant at Golden; also large leaves of *Magnolia*, *Myrica* (formerly *Dyandroides*), distinct species of *Quercus*, a *Viburnum* whose leaves are as large as those of a *Platanus;* southern types of *Sapindus*, *Rhus*, *Ilex*, and *Juglans*, with entire leaves.

Prof. Heer remarks on another character of the Eocene flora of Mt. Bolca, a negative one, which is perfectly recognizable in our Lower Lignitic flora. It is the great scarcity or nearly total absence of some families and genera of plants: the *Conifers*, *Salix*, *Populus*, *Alnus*, *Ulmus*, *Betula*, *Planera*, *Corylus*, *Acer*, *Tilia*, *Carya*, etc. All these forms of leaves with serrate borders are mostly absent from our Eocene as well as from our Cretaceous floras. They appear at a higher stage of the Tertiary, first at Evanston, more abundant still at Carbon, and still more in the Upper Miocene flora of the Green River group.

The second objection of Dr. Newberry is: *That the tuberculate fucoid Halimenites, considered by me as a diagnostic of the Eocene, is in New Mexico the most characteristic plant of the Cretaceous sandstone.*

But this so-called Cretaceous sandstone with *Halimenites* is, most probably, the heavy sandstone which underlies or intersects the Lignitic, wherever it has been observed, in Colorado, New Mexico (as far south as Trinidad, at least) and Wyoming. It is therefore the question now at stake, to know whether this formation is Eocene or Cretaceous: and it cannot be decided by a mere affirmation. We cannot say anything about the flora of those so-called Cretaceous strata of New Mexico, observed by Dr. Newberry, before his fossil plants are published, or before any thing pointing out their exact geological relation is ascertained. Even the proximity to what he calls the gypsiferous marls proves nothing; for the Dakota group, which appears to be a shore formation, does not extend far to the west, and to my belief does not reach New Mexico. If it is so, the Lignitic there should be in close proximity to the Permian. But this is mere surmise, and I will not go out of my defensive position. It is for Dr. Newberry to furnish sufficient evidence on the geological age of the Lignitic strata which he has observed in New Mexico, and when he has done it as positively as I have for the Lignitic of Colorado, I shall certainly be prepared to accept his decision.

To return to the second objection expressed above, I refuse to accept as my own the assertion, *that the tuberculate Halimenites is a diagnostic of the Eocene.* I have merely remarked that Prof. Meek and other paleontologists have found it in all the strata like those of Coalville and of Bear River, where no other kind of fossil plants has yet been discovered, and which therefore have not furnished to vegetable paleontology any other evidence of their relation to the Eocene. As it is found in abundance, and everywhere in connection with the Lower Lignitic sandstone, I had to consider this fossil as a kind of leading species of this formation. But I positively remarked (p. 345 of Dr. Hayden's Report) upon the great quantity of fucoidal remains in the Lignitic sandstone of the Rocky Mountains, as in the Eocene of Europe, comparing the distribution of this class of plants in both formations. It is not therefore this *Halimenites* only which is a *diagnostic of the Eocene sandstone*, but the prodigious quantity of the fucoidal remains of numerous species. And this character, when I saw it so distinctly marked in the Raton Mountains, forcibly recalled to me the essential facies of the Mount Bolca and of the Flysch Eocene flora of Europe.

In the same way Dr. Newberry has misapplied what I said of the great abundance of Sabal leaves, as indicating the Eocene age of the Lignitic. Contradictory to this assertion, he says, *that Sabal and Palms are common enough in the Miocene.* Who doubts it? We have Sabal leaves in the Pliocene of California; we have Sabals living at our time and in our climate; why not in the Miocene? I considered the presence of Sabal in all the strata of the Lower Lignitic as a proof that *they are not of Cretaceous age.* No Sabal and scarcely any trace of palms have as yet been recognized in the Cretaceous of any country.* This cannot be negatived by asserting that they are common in the Miocene. I have remarked already that all the fossil species of Sabal described by European authors have been found in the Eocene.

The third objection of Dr. Newberry is *that Prof. Meek, Marsh, Cope and Stevenson, guided by molluscous and vertebrate remains found in the Colorado Lignite deposits, consider them Upper Cretaceous.*

Though these geologists have perhaps considered the lignites of Colorado as Cretaceous, I do not know that they have found, in support of their opinion, any paleontological evidence. Prof. Meek, according to his own statement, has not found any Cre-

* One *Flabellaria, F. longirachis* is described by Unger from a Cretaceous formation of Muthsmannsdorf in Austria, and one, *F. chamæropifolia* Göpp., from the Quadersandstein of Silesia. As remarked by Schimper, they belong to a peculiar type of palm.

taceous shells in the Lignitic of Colorado. Those of Golden come from the clay underlying the fucoidal sandstone. Why did not Dr. Newberry quote Hayden's opinions? No geologist has seen so much of the Lignitic, or has studied it so carefully as he has. Everywhere, in connection with the Lignitic formation, he has seen this sandstone, which he calls either *beds of passage*, or *of transition*, or *positively Eocene*. He has even found in Colorado one specimen of *Inoceramus* at its base. I have discussed the question of the so-called Cretaceous evidence by Mollusks in Hayden's Report (1872, p. 341), and will not repeat here what the critic could have answered by pointing to positive facts, if he had had any in contradiction of my assertions. But, in order to meet any farther discussion on this subject, I will take the case as it is clearly stated by Dr. LeConte, in his notes on the Geology of the Rio Grande.

He makes the following objections to my opinion on the Tertiary age of the Lignitic. I quote only those which directly bear on the question.

1*st. That the lignite beds west of the Rio Grande were found by Dr. Newberry in supposed Jurassic strata, and in the super-adjacent lower Cretaceous sandstones.*

2*d. That the lignite beds of the Rio Grande Valley are in such close proximity to the gypsiferous marl series as to require their reference to our Western Early Cretaceous, the Dakota group.*

3*d. That the beds of the Raton Mountains are undoubtedly Cretaceous, since both Mr. Owen and himself have obtained Inocerami in the sandstone containing coal.*

5*th. That M. Berthoud, as quoted by Hayden, found, in* 1862, *a bed of coal almost identical with the Golden City bed, with bluffs one and a half miles north, containing belemnites, etc.*

6*th. That Gen. Pierce obtained on each side of a coal-bed near Platte Cañon, ammonites, baculites, etc.*

On the first and second paragraphs, I can but repeat my former statement: that we know as yet nothing of the lignite beds of the Rio Grande and southern New Mexico, and have to wait for evidence from their fossil flora to certify their age. Dr. LeConte, however, states, on page 40 of his notes, a fact which seems to me contradictory to what he is endeavoring to prove. It is: *that from the proximity of the marl series, the absence of characteristic shells of the Middle and Upper Cretaceous, and the known existence (by Dr. Newberry's report) of Lower Cretaceous lignites west of Rio Grande, he infers that the anthracite beds (the Placière coal), belongs to that period, and that all the beds of which he has information along the valley are of the same age.*

I admit this last statement, that these beds are all of the same age. And as among the fossil plants found in connection with that Placière anthracite are Sabal leaves, sent to me by Dr.

LeConte,* I consider it as Eocene. And if, as I remarked above, the Dakota group does not extend to New Mexico, this explains the absence of the characteristic shells of the Middle and Upper Cretaceous, and the position of Tertiary lignite in proximity to the marl series.

On the third paragraph of Dr. LeConte, I have nothing to remark but this: that the shells reported from Dr. Owen's and Prof. Cox's exploration were found, as positively recorded in the note and the section of Prof. Cox,† at the base of the black shales (Cretaceous, No 4 of Hayden), which everywhere at the Raton Mountains, and from Trinidad to the Spanish Peak, underlies the Eocene sandstone which supports the Lignitic.

The discovery of Cretaceous shells half a mile north of a bed of coal, by my friend Capt. Berthoud, does not indicate that the strata-bearing shells overlie the coal. At Golden, the distance between the clay-bearing Cretaceous shells and the Lignitic sandstone and coal leaning against it is not more than a few rods. The Lignitic, however, overlies the Cretaceous. And, for the assertion of Gen. Pierce concerning a bed of coal on the Platte, with Cretaceous fossils on both sides, as nobody, not even Dr. LeConte, under the guidance of Gen. Pierce, has found this coal, it has to be erased from the page of reliable documents. All along the base of the mountains, especially from Platte Cañon to Coal Creek, the Tertiary and Cretaceous strata are much disturbed, often folded and crushed vertically against each other, and their relative position is very difficult to ascertain.‡

What is left then of the repeated assertion that fossil shells and bones of Cretaceous age have been found in the Lignitic basin of Colorado? A single, badly-preserved specimen of *Inoceramus*, found at the Raton Mountains, where the same locality has been visited by a number of geologists and explorers, and where none other has been discovered. I do not say this to throw the slighest doubt on the reality of the discovery, for I well know that a number of Cretaceous animal remains are found in Wyoming over beds of lignite. But I

* Dr. Hayden found at the same locality, *Populus balsamoides*, *Ficus tiliæfolia*, *Cinnamomum Mississippiense*, *Magnolia*, etc., all Eocene plants.

† Prof. E. P. Cox, in letter, April 6th, 1874.

‡ Since writing this, a most valuable and detailed letter, received from Capt. Berthoud, settles this question, as follows: "1st. That if Mr. Stevenson observed Inoceramus, Baculites, etc., in superposition to the lignites, it was clearly a case of local inversion; i. e., that, as shown in our lignitic basin, it has been so tilted up that with the coal seams near it, it was thrown over the perpendicular. 2d. That as remarked to Prof. LeConte, I found in the locality named a coal bed whose dip could not be ascertained, as it was badly cut by the drainage of a small gully. In bluffs north or northwest, I found several Baculites that seemed to come from a clay bed in the bluffs; but whether the coal was superposed to the clay or the clay to the coal, I could not say." All the remarks in this letter and sections of the localities are positive evidence of the Tertiary age of the Colorado Lignitic. More of it will be quoted in my report.

remark on this, in order to meet and to answer another unjust rebuke of Dr. Newberry, who, after repeating his assertions of the discovery of Cretaceous animal fossils over the Colorado lignite deposits, says:—"*That I point to my* 250 *species of fossil plants, claiming that they far outweigh the testimony of the animal remains.*" And adds: "*In fact, however, these fossil plants have very little bearing on the question.*"

The above is also, to say the least, a colored representation of my statements. To answer the objection that at Black Butte, Coalville, Bear River and other localties in Wyoming, the Lignitic beds and sandstone-bearing plants have been recognized underlying strata with fossil Cretaceous animals, I had to examine, if, from the nature of its compound and from its vegetable remains, the Lignitic formation should of necessity be considered as a whole, or, if it could be separated in two members, one representing the Upper Cretaceous, the other Lower Tertiary. For this examination, of course, the essential documents to be considered in view of my special researches are the fossil plants. From the large number of Fucoids in the Lignitic sandstone, from the identity of species of these marine plants found by Mr. Meek in connection with Lignitic strata as far down as the arenaceous beds bearing Cretaceous animal remains; from the prodigious preponderance of Palms, recognized also in the same circumstances from New Mexico to Wyoming, etc., I forcibly admitted the unity of the Lignitic formation, in its whole, and therefore limited the discussion to this point: the Cretaceous or the Tertiary age of the formation. In order to strengthen my position in regard to the value of the conclusions afforded by vegetable remains, I compared the Lignitic formations to those of the Carboniferous epoch, remarking that, having positively a preponderance of land-plants over marine animals, or a land character, they should be considered as land formations, and that therefore the evidence given by the fossil plants should outweigh in importance that of some Cretaceous animal remains, whose presence could be considered as of a casual occurrence, etc. That in every geological formation, especially in every land formation, like that of the Carboniferous, fossil animal types were more or less in non-coincidence with the vegetable forms, in regard to the data furnished by them respecting the age of the formations. For, in the Carboniferous, we find Devonian mollusks far above the Millstone grit, and also Permian shells far below the base of the Permian, even as far down as the middle of the Carboniferous measures. These, however, are nevertheless admitted now by everybody to constitute a single homogeneous formation, which is not modified in its essential points — the coal beds and their plants—by the introduction of some foreign species. Contrary

to the assertion that the fossil plants have little bearing on the question, it is clear, therefore, that it is from the evidence furnished by vegetable paleontology that the question has to be decided.

I have been, however, careful to consider the data furnished by animal paleontology in regard to the age of the strata. I have quoted Prof. Meek's passage of a letter where his opinion is recorded rather in favor than in contradiction of mine. I could have remarked too that he has even found at Black Butte and identified fresh water shells of the species of the Upper Missouri Eocene: that, too, certain species of shells found in the same bed with Prof. Cope's Dinosaurus are hardly distinguishable from modern species, etc.

Prof. Cope's conclusions, in his Review of the Vertebrata of the Cretaceous, &c., which is just published, do not in the least interfere with my own. They prove only the non-coincidence of animal and vegetable types in some formations; and all my remarks on the presence of coal-beds formed from land-plants and of vegetable remains as furnishing the logical characters of the formation, have their full value. This discordance is less embarrassing in a case like this than it might be in the case recorded by Pictet, who derived from a detailed study of the animal fossils contained in the Cretaceous strata of St. Croix, Switzerland, and a comparison with contemporaneous repositories, an argument in favor of the idea propounded by Barrande: that two successive faunas must necessarily have existed together for some time. He concludes this remark by showing that paleontological faunas distinguished throughout by marked characters are not ordinarily susceptible of any rigorous limitation. That may be. But if Tertiary and Cretaceous faunas are regarded as contemporaneous, even inhabiting the same repositories, we may still more easily admit that a Cretaceous fauna and a Tertiary flora have sometimes succeeded each other in alternate strata. It is all that is proved by the researches of Prof. Cope in relation to my own.*

From the same considerations I continue to admit the Lignitic of Vancouver Island as Eocene, on account of the character of its fossil leaves, the abundance of palms, etc., even against the assertion of Dr. Newberry, that this formation is Cretaceous. These leaves were sent to me by Dr. Evans in 1858, and my opinion of the Tertiary age of these fossils was, according to his letter, in perfect concordance with his views, and with the evidence furnished to him by his geological or stratigraphical

* In the north of France, Eocene beds are overlaid or mixed with strata bearing remains of Cretaceous animals which all disappear to the south. On this Saporta remarks that the Cretaceous fauna has persisted for a longer time toward the north. The same observation, precisely, could be repeated on comparing the Lignitic of Colorado with that of Wyoming.

observations and by the fossil mollusks. From a recent re-examination of these leaves, I find no trace among them of any species which could be compared and referred to Cretaceous plants known till now. They bear the characters of the Eocene flora, while those of Bellingham Bay, which I considered at first as of the same age, appear referable to the Lower Miocene or to an upper stage of the Eocene by the predominance of serrate leaves: *Planera*, a large species of *Salix*, *Quercus Gaudini*, recognized in the Upper Miocene of Italy, *Diospyros lancifolia*, abundant at Evanston, etc. The presence of Cretaceous animal fossil remains, above the coal of Vancouver, could merely indicate the same disagreement between the vegetable and animal remains as at Black Butte.

From the descriptions of the species of so-called Miocene plants published in Dr. Newberry's notes on Ancient Floras, etc., it is evident that the specimens furnished to him for examination have been mixed, or have come from different localities, and represent different horizons. He has, as Upper Miocene, a preponderance of Coniferous remains, especially *Taxodium distichum*, *Thuya*, *Glyptostrobus*, and *Sequoia*, which all abound in the shale specimens sent this year by Profs. Hayden and Cope from South and Middle Parks, as they have been sent before from Elko Station and Green River with *Planera*. He has *Populus Arctica*, species of *Alnus* and *Corylus*, in common with the Middle Miocene of Carbon. With Evanston he has the fine *Carya Antiquorum*, which abounds there, *Juglans rugosa*, *Platanus nobilis*, etc.;* and with the Lower American Eocene he has *Platanus Haydenii*, *P. Raynoldsii*, *Cornus acuminata*, which I consider as identical with *Juglans rhamnoides*, and, too, the same large proportion of *Sabal* leaves. In the collections brought from long explorations extended over wide areas, the mixing of the specimens is unavoidable, and personal explorations only give full evidence in regard to the information furnished by paleontological data. In my first examination of Prof. Hayden's specimens, which too were somewhat mixed, I made a mistake of the same kind, accounting for difference of types in local floras by a difference of temperature, while it merely indicated different horizons. My explorations of the past two years have therefore forced me to modify some of my views on the distribution of our Western Tertiary flora, and to fix, for the present at least, the groups in the following order, as published in Prof. Hayden's report of this year.

1. The Lower Lignitic: that of Black Butte, the whole Colorado basin as far south into New Mexico as the Placière anthracite coal has its flora, *Eocene:* Lower Eocene for America.

* These fossil plants of Dr. Newberry are known to me by the examination of the specimens from which the species are described, and which I have compared in the museum of the Smithsonian Institution.

2. The Evanston coal is, by its types, half Eocene, half Miocene, referred as yet to the Upper Eocene.

3. The flora of Carbon is positively Middle Miocene.

4. That of Green River, Elko Station and the Parks is of Upper Miocene type.

Having thus fairly considered and answered all the critical observations of Dr. Newberry, I will end the discussion by passing over to his ground and proposing a single question which I should like him to answer.

He positively regards the New Mexico Lignitic as Cretaceous. From his admission, the Colorado Lignitic is of the same formation; for, though he says that he has not seen it, he is positive that a number of geologists have found there Cretaceous animal fossils. As the Wyoming Black Butte coal has the *Deinosaurus* imbedded in its roof shale, this bed, like the underlying Lignitic, is also Cretaceous. It is therefore a single undividable formation. Now, we find at Black Butte, together with a great abundance of Sabal leaves, a number of the species described by Dr. Newberry in his Ancient Floras; *Cornus acuminata** is especially abundant there. With this we have too the fucoidal remains and, more numerous than any other species, the *Halymenites*. At Golden, we have a still larger preponderance of Sabal and of Fucoids too, and preponderance of *Platanus Haydenii*, *P. Raynoldsii*, the same *Cornus acuminata*, *Rhamnus elegans*, etc., etc. All these species, according to Dr. Newberry, are positively Miocene. This comparison could be pursued in the same way at the Raton Mountains, with the same result: Plants, Fucoids, and Cretaceous mollusks (which of course prove to Dr. Newberry that the formation is Cretaceous), and at the same time, in the same strata, those leaves identical with the species described by the same author from the Upper Missouri, and which to his knowledge represent the Miocene. Which then will he prefer? If these strata are Cretaceous, his plants of the Upper Missouri are Cretaceous plants, a supposition which he can not admit. If he insist that they are Miocene plants, our Lignitic formation is Miocene as a whole, and here he will meet all the geologists and paleontologists whom he has quoted as authority, and his own assertions too, far more antagonistic to his Miocene than they are to the Eocene of mine.

It will not do to say that a Cretaceous Lignitic flora may have some Miocene species and be Cretaceous all the same, especially when no Cretaceous species is recognized in it. After all the points of comparison and the facts mentioned in these remarks, after the assertion of Dr. Newberry that the palm leaves are evidently Miocene and the *Halimenites* as evi-

* A species far different from *Cornus acuminata* Web.

dently Cretaceous, the occurrence of these two kinds of vegetables in contiguous strata (the Fucoidal remains being even found higher than the Palm leaves), thwarts any attempt to a conciliation of this kind. It will not do either to say that the Lignitic represents at one place the Cretaceous, at the other the Miocene; for, even considering the assertion of Dr. Newberry contrary to mine, that vegetable paleontology has nothing to say in this matter, animal paleontology has sufficiently proved the continuity, the uniformity and homogeneousness of the formation.

These remarks have to be limited to what is directly related to the age of the Western Lignitic flora, and even in a paper like this I have to present them in a condensed form and without the details which might have given some more light to the subject. Those who are interested in this matter will find it discussed at length in Dr. F. V. Hayden's Report of the explorations of 1873. I will omit also to consider the speculations on the wanderings of the Floras in Europe during the geological divisions of Cenozoic time. We have enough to do and more pressing work in the study of our own materials. As the European paleontologists know very little as yet of their Eocene floras, and nothing whatever of their Pliocene, all those theories on the "march and countermarch" of the floras according to the upheaval of chains of mountains are merely imaginary.

Columbus, Ohio, April 14th, 1874.

Art. LII.—*On Helderberg Rocks in New Hampshire;* by C. H. Hitchcock.

[Concluded from page 476.]

Littleton area of Helderberg.

I have a number of sections crossing this area.* The first is one at the northeast extremity, extending from Palmer to Burnham's Hill, nearly one and three-fourths mile. Palmer Hill is composed of Lyman schist, dipping 78°, N. 28° W. This and the following are compass courses. In passing to the depression (which is in reality a watershed for the streams flowing northerly and southerly), the strata first stand perpendicular; they then dip northwesterly; and finally several measurements in a distance of thirty rods gave S. 34° E., 80°, S. 10° E., and 85°, S. 35° E. The rock here (Closson's) is an indurated slate, chiefly siliceous. Next we pass up a hill, over the Lisbon

* The courses of all the sections are indicated upon the map, page 471.

schist perhaps, dipping 80°, S. 15° E. On top of the hill there is a siliceous rock, which from different observers has received the names of sandstone and buhrstone; it dips sometimes northwest, but perhaps oftener to the southeast. On the north slope of the hill, the sandstone varies in position from about 80°, S. 8° E. to S. 8° W. This rock can be followed a mile northeasterly across the road going eastward to Mann's Hill, and then is supposed to turn and follow up the hill to the southeast of Burnham's house, and to continue southwest to Parker River. It has its maximum development on the east side of the basin, constituting what would be called a mountain range in many parts of the country. It probably connects with the buhrstone of fig. 3.

Overlying the sandstone, as I suppose, is the fossiliferous limestone. It has been excavated at several places quite extensively, and burnt in a contiguous kiln. It is usually of a light drab color, somewhat brecciated, and the fossils are not conspicuous, but upon search they prove to be considerably abundant; the thickness varies from ten to fifty feet. On the north side, the limestone forms a precipice of twenty feet, in consequence of excavations. In contact with it on the section line is a slate dipping S. 20° E. I find it also stated in my notebook that there is there a chloritic rock and a rough mixture of quartz and feldspar, and also the fact of a change of a quadrant in the strike, in a few rods distance. The overlying slate is seen to best advantage in descending the hill toward Littleton. It is rather dark, soft, splits readily and contains fucoids and markings like *Chondrites*, and dip ssoutheast. The top of this hill is an excellent place to observe contorted strata, and on account of their variation in position it is difficult to be satisfied with any interpretation of them. Professor Dana visited this locality, as well as the region along Parker Brook, in 1871.

I do not suppose that all the facts are indicated by so even a synclinal as appears in the figure. There may be hummocks of underlying rocks to disturb the continuity, and the strata are certainly contorted. The limestone was not observed to the east of Mr. Burnham's house, but, as the sandstone beyond has a small reverse dip, we may presume that the limestone changes with it. Still farther to the southeast gneiss occurs. The country is wooded and slopes rapidly, and would not be likely to afford good ledge exposures.

A mile to the southwest a more satisfactory section is obtained, so far as the position of the strata is concerned, but the limestone has not been observed. The west end lies in a valley, one of the tributaries of Parker Brook, and the rock is chiefly the chloritic rock of the Lisbon group, dipping a few

degrees, S. 10° to 20° E. The ground is cleared and the ledges common. The junction between this rock and the slates can be seen to the best advantage near A. Mill's house. At the house the slates dip 85°, N. 10° W., and a short distance southeast 70°, S. 20° E., showing a small anticlinal where the rock was crowded hard. The schists, including calcareous limestone. a drusy rock, and diabase, dip 85° N. 70° W. At A. P. Hubbard's, exactly upon the section line, the dip is 85°, S. 20° E. The soft clay slate is thin-bedded, jointed but not contorted. The same position continues two-thirds of the way to J. Shute's house. The last third of the way, the slate resumes the dip of N. 20° W., and disturbances are common. The cleavage planes can also be distinguished from the strata in a few ledges. The quartzite is a rough-looking rock, somewhat like buhrstone, dipping even as low as 35°, N. 20° W. The band of chlorite schist is known by a specimen, and is supposed to correspond to a similar rock in the next section, holding the same position. Last of all is the gneiss, dipping at a moderate angle in the same direction, and probably underlying unconformably the whole series described. This section is 420 rods long. The slate is estimated to be 1490 feet in thickness.

The slate is continuous from figs. 2 to 3, gradually narrowing, and disappearing before reaching the section in figure 4; that which appears on the latter occupies a slightly different line. Fig. 3 crosses the best locality of buhrstone, from E. P. Miner's, upon a tributary of Parker Brook, and one-eighth of a mile north of the Littleton cemetery. It is 160 rods long. The western edge of the gneiss appears at Miner's. The chloritic layer is concealed by drift. The buhrstone crops out on the hill side; it is quartz, massive and brecciated, sometimes jaspery, opaline, with a multitude of seams covered by quartz crystals. About forty feet in thickness of it are exposed. Following up the hill, we find next the slates, the limestone being concealed by drift. It appears in place only a few rods to the south of the section. The slate is bent everywhere, and shows a tendency to contain drusy quartz. Two measured dips are 70° N. 60° W. and 85° N. 70° W. Other strikes are more easterly. The section, if continued, would pass down a precipitous hill and across Parker Brook into a swampy forest.

This is the most important of the sections, partly because it is near the travelled road to the Connecticut River west from Littleton village. It is one mile and three-eighths long. The gneiss is the Oak Hill deposit, and is in place one-eighth of a mile north of the section, with a dip of 35°–40°, N. 20° W. The chloritic rock appears next. It is close by the road, opposite the last house before reaching Parker Brook, and can be traced along the ridge extending northeast for one-fourth of a

mile. The dip is 60°, N. 50° W., with a somewhat higher dip down the slope.

The fossiliferous limestone follows immediately. The first layer seems to conform with the wall rock. At the kiln, which is not fifty feet from the base, it dips 60°, E. 5° S., and also westerly. Hence there is a small anticlinal axis. Directly at the kiln no fossils were obtained; they come from a dark layer with a westerly dip nearer the brook. The *Zaphrentis* and the *Favosites* with small crinoidal fragments are found here. Geologists have searched for fossils at the kiln, and finding none have concluded that our story about them is a myth; but they should look in the right place. Dr. C. T. Jackson visited this kiln in 1841. He says: "The bed is included in mica slate, embraced on both sides by granite, which crowded the limestone in such a manner as to produce contortions of the strata. The course of the limestone, as indicated by strata marks, is N. 20° E., S. 20° W., and its dip is to the northwest." He figures the bed as enclosed between two masses of granite, but does not exhibit any contortions in the strata.*

The alluvium of Parker Brook intervenes and conceals the rock for an eighth of a mile perhaps. On the southwest side there are several outcrops of limestone—some of them containing coral masses. A slaty mass with no cleavage is mixed with it. The limestone near the first house on the west side of Parker Brook is bluish, and was at first supposed to belong to the Lisbon series—as it is not fossiliferous. It has been excavated for a kiln in years gone by. Recent researches indicate that the whole of this hillside, perhaps into Lisbon, is all of Helderberg age. The strata have somewhat of a zigzag arrangement, which need not be described in detail.

Directly beyond the brick kiln we find the chloritic rock in its perfection, dipping in the same direction with that already noted, but at a steeper angle, and the range is only thirty rods wide. At a turn in the road slate of less width, seemingly vertical, appears, and we discover imbedded in it two feet in thickness of compact crinoidal limestone. This identifies the slate with the deposit upon Fitch Hill, a quarter of a mile to the southwest, where the *Pentamerus* is found. The mingled slate and limestone extend up the hill and then across the ridge.

The chloritic rock re-appears on the section at a fork in the road, and continues uninterruptedly for three-eighths of a mile, dipping 75°–80° northwesterly. This would give a thickness of about 1,900 feet of strata. This is undoubtedly continuous to the west end of fig. 2 in one direction, and to the slate quarry in the other, a distance of about three miles.

The Fitch Hill locality was discovered Sept. 22, 1873. Mr. J. H. Huntington and A. S. Bachellor of Littleton and myself

* Final Rept. Geol. N. H., p. 108.

composed the exploring party, and Mr. Huntington first detected the presence of the *Pentamerus*. Our attention was called to the spot by Mr. A. R. Burton of the village, who had seen limestone there. It is about fifty rods southerly from E. Fitch's house, in an open pasture near the forest, and above an orchard. The first rock seen above Mr. Fitch's is the diabase,* running N. 65°–70° E., and containing a layer of white quartz. In the pasture the strike changes to nearly east and west, and this fact is made certain by the position there of the white quartz, which curves with the diabase, but may be a little nearer the Helderberg after the bend is passed than before. This is confirmed by examining the rocks east of the Helderberg range. On fig. 4 below, there are thirty rods of chloritic rock east of the slate range, but on Fitch Hill, in consequence of the transverse course of the slate, it lies on the southeast of the diabase altogether, as shown in fig. 5. To the southwest there is another outcrop of this range of diabase, because the Helderberg is cut off by it, but the fossiliferous seam again covers it when the low ground is reached, and the hard rock is seen no more.

Furthermore, the contact between the Helderberg and diabase on Fitch Hill is not a direct succession or interstratification, since there has been a sliding of one rock over the other. The removal of the turf revealed a slickensides between the two. As expressed by Pres. W. B. Rogers, who examined the locality with us a few days later, it "looks as if the limestone had backed up on to the green rock" These facts are mentioned to show our reasons for believing that the Helderberg rocks on Fitch Hill and the neighborhood overlie the Lisbon group unconformably.

The order of the rocks from Fitch's house to the very summit of the hill is well shown in fig. 5. What I have called the top of the hill thus far signifies the highest part of the cleared land. This section reaches the very summit, which is wooded. Above the Lisbon series, or the diabase, come about fifty feet of Lower Helderberg limestone, holding the *Pentamerus* and a Gasteropod, with the others mentioned by Mr. Billings. This is followed by forty or fifty feet of coralline slate; thirty or forty feet of friable conglomerate, white when weathered, like the Oriskany sandstone of New York, the quartz pebbles being of the size of kernels of Indian corn. Next is a bluish, somewhat siliceous limestone of two sorts. Then follows considerable tough, massive hornblende rock, with no signs of stratification and a strange associate of the Pentamerus limestone. On the very apex of the hill is a sandstone weathering white, but

* Prof. Hitchcock says elsewhere that his "diabase" is not known to contain labradorite, and may be some other rock; it is metamorphic.—J. D. D.

Fig. 1.—Section from Palmer Hill through Burnham's lime quarry. 1, Lyman group; 2, Palmer Hill; 3, Closson's house; 4, Lisbon group; 5, Farr Hill; 6, Quartz; 7, Helderberg limestone; 8, Slate; 9, Burnham's house; 10, Quartz.

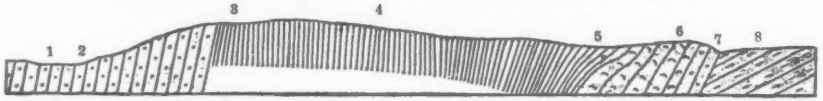

Fig. 2.—Section from Crouch's to Shutes's. 1, Crouch's house; 2, Lisbon group; 3, A. P. Hubbard; 4, Helderberg slate; 5, Shutes's house; 6. Quartzite; 7, Chlorite band; 8, Gneiss.

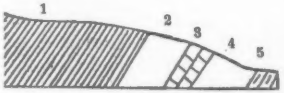

Fig. 3.—Section through Buhrstone. 1, Slate; 2, Limestone?; 3, Buhrstone; 4, Place of Lisbon group; 5, Gneiss, near E. P. Miner's.

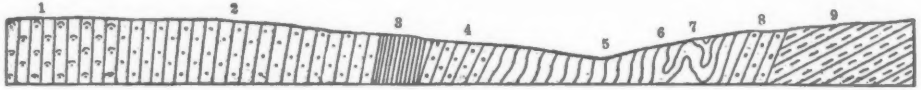

Fig. 4.—Section along carriage road westerly from Littleton village. 1, Green schists; 2, Diabase; 3, Helderberg slate; 4, Diabase; 5, Parker Brook; 6, Helderberg fossils; 7, Lime quarry; 8, Chloritic rock; 9, Gneiss (supposed).

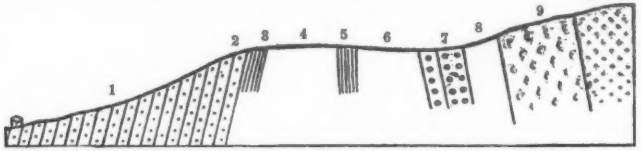

Fig. 5.—Section southerly from Fitch's house. 1, Diabase; 2, Quartz; 3, Slates; 4, Fossils in limestone; 5, Slates; 6, Limestone; 7, Conglomerate; 8, Siliceous limestone; 9, Hornblende; 10, Sandstone.

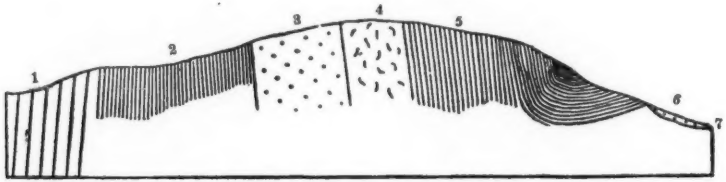

Fig. 6.—Section from Quarry Road to L. A. Parker's. 1, Chloritic rock; 2, Fossiliferous slates; 3, Sandstone; 4, Hornblende; 5, Dark slates; 6, Sand; 7, L. A. Parker's.

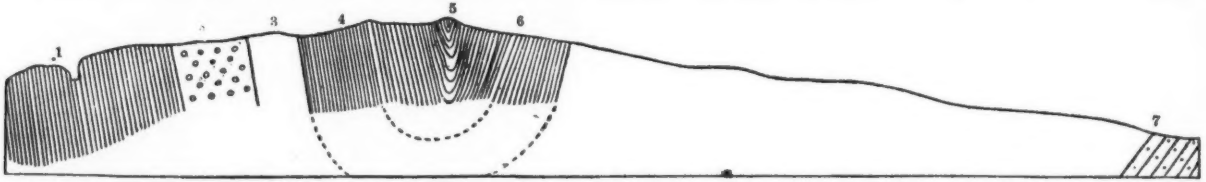

Fig. 7.—Section from Slate Quarry to the Ammonoosuc River. 1, Slate quarry; 2, Conglomerate; 3, Greenish schist; 4, Dark slates; 5, Light-colored sandstones; 6, Dark slates; 7, Green schists.

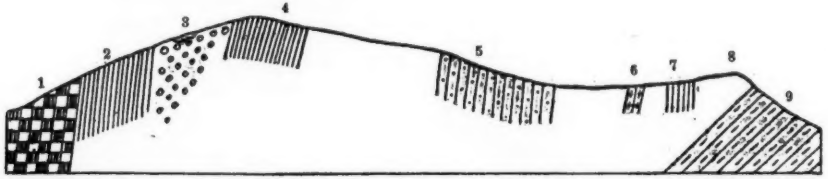

Fig. 8.—Section from Mulliken's Brook to North Lisbon. 1, Lyman group, near G. D. Shute's; 2, Helderberg slates; 3, Conglomerate?; 4, Dark slates; 5, Lisbon group; 6, Mica schists; 7, Hornblende rock; 8, Conglomerate, Swift Water?; 9, Gneiss.

Fig. 9.—Section up South Branch, N. Lisbon. 1, Gneiss; 2, Conglomerate; 3, Slates; 4, Conglomerate; 5, Slates; 6, Lisbon group; 7, Coos group, staurolite slates.

gray in the interior. It dips apparently 50° east of north. The section is about half a mile long.

Following the limestone southwest, perhaps a fourth of a mile, we find the purest carbonate of lime yet seen. This is interrupted by chloritic rock, to be succeeded by fossiliferous slate and limestone, which passes west of the slate quarry and lower down the hill if its strike does not alter. Commencing near the fork in the road turning to the slate quarry, there is first the diabase on fig. 6, with its usual position; second, the Helderberg rocks just mentioned. The slates predominate and decompose readily and unequally. High up the hill is the gray sandstone decomposing white, continued from section 5. The hornblende rock on the crest of the hill is one massive stratum, with no indication of divisional planes. The slates were at first thought to be the continuation of the quarry ledge on fig. 7. Both have the pyrites in abundance and the same general aspect. But by comparing the several figures together, it seems as if the sandstone would correspond with the conglomerate back of the quarry, and the hornblende rocks agree with the green schist. That would make the slates just mentioned correspond with each other, as well as the harder dark slates in which a synclinal appears.

The latter slate is a hard, black, even-bedded rock, which also shows itself continuously nearly to Parker Brook. The east part of the synclinal is wanting in fig. 6, its supposed place being covered by the alluvium of the Ammonoosuc. The strike varies to northwest near Mr. L. A. Parker's house, at the east end of the section, and the rock makes a part of the zigzag arrangement before alluded to.

The next section passes from the slate quarry to the Ammonoosuc River near the south line of Littleton, one mile and seven-eighths long, and seven-eighths of a mile southwest from fig. 6. The same hill is traversed as before, but the upper slates are better displayed. They are covered by two grades of argillaceous sandstones, the lower portion being more argillaceous and of a darker color, the upper grayish and of a different texture from the sandstones on figs. 5 and 6. The hill was crossed transversely as far as indicated; the eastern slope remains unexplored. The strike varies N. 75° E. to N. 80° E. There seems to be an outcrop of the Lisbon group dipping toward Blueberry Hill in the valley east.

The slate quarry is a location known to residents on account of extensive excavations once made there. The slate is of excellent quality, and, were it not for a profusion of cubical crystals of pyrites, would be worth quarrying. It dips about 80° southeasterly. Above it on the hill is an interesting conglomerate, with pebbles averaging the size of a hen's egg. The

paste is the slate of the quarry. One pebble is a foot long. Siliceous fragments of a dark color predominate, which seem to have been derived from the Lisbon group, as have been a few greenish chloritic bits. Others, and possibly the greater portion, show resemblances to the compact feldspars of the Labrador group. There are small bits of black slate like that occurring near the east end of fig. 6.

The next section in fig. 8 is three and three-eighths miles long, and passes over more strata. It commences high up the early course of Mulliken's Brook, crosses Blueberry Hill, and terminates a short distance north of North Lisbon, reaching the gneiss. At the beginning is the Lyman instead of the Lisbon group, though the latter would appear if the section had been elongated half a mile. Near G. D. Shute's house and "Indian Rock," these schists dip 85°, N. 20° W. The east border of this group dips 80°, N. 30° W. It weathers whitish, presenting a chalky aspect at a little distance. Along the carriage road succeeding is an extensive range of Helderberg slates and limestones containing *Favosites*. The strata stand perpendicular, running northeast. On a tributary stream, near C. Hastings's house, is a fine exposure of grit, slates and calcareous beds, greatly resembling fossiliferous strata in Maine and New York, but they yielded no relics of life in a half-hour's search. This series of strata forms a steep cliff seventy or eighty feet high, which can be followed a mile and a half to the slate quarry. The country at the base of the cliff is everywhere a swampy forest not intersected by roads, so that its exploration is not inviting.

Passing up the hill, there are so many boulders of conglomerate that we must believe this to be the rock in place. Its character does not vary from that seen on section 7. This view will make the fossiliferous slates correspond with the slates at the quarry. Near the top of Blueberry Hill are slates with the course N. 65° E., and irregularities which may be explained by supposing cleavage planes to be present having a different strike from the strata. On the crest of the hill the slates dip 70°, N. 25° W. This continues about half a mile on the line of section, or as far as I was able to travel upon it. There is room enough for the double thickness of slate seen in fig. 7.

The eastern slope has not been examined throughout. About half way down I have twice examined ledges apparently of the Lisbon group dipping toward the hill. Mr. Huntington travelled over the remainder of the section, and his specimens seem to indicate, first, the mica schists of the Coös group, (6) followed by considerable hornblende rock, (7) and lastly by a conglomerate (8) with whitish cement and pebbles of the size of

buck-shot. This rock stands on edge on the top of the hill next the Ammonoosuc River, and, with the mica and hornblende schists, is perhaps our Swift Water series. The hornblende may connect with a large mass of the same rock a mile southwest, it being in contact with Helderberg there. The hornblende may correspond with the same rock on figs. 5 and 6. The mica schists evidently belong to the Eustis Hill series, to the south of Littleton village, possibly disconnected from that outlier by erosion.

The gneiss at the southeast end is part of the area known as "Bethlehem gneiss," or rather the common variety upon its border. The mica is black, and the feldspar often scanty. The position differs from that of the other rocks. Its normal position is about 40° dip toward the north, both the inclination and course varying from those of the other strata that have been cited.

This section, if protracted, would cross another interesting Helderberg area; but for the sake of clearness, I will add a small section (fig. 9) with greater horizontal scale, situated about a quarter of a mile to the southwest, crossing the Ammonoosuc nearly at North Lisbon railroad station and passing up its "south branch." The gneiss dips 36°, N. 35° W. at the "Lead mine." Next is a coarse conglomerate, seen in the field and under the bridge, dipping 65°–70, N. 10° W. As there is a general resemblance between this and the conglomerate of the Lisbon group, it was not till the recent discovery of extensive Helderberg strata that these ledges at North Lisbon appeared to belong to the Paleozoic series. The materials of the pebbles are white and blue quartz, hydro-mica schist or Lisbon group, two or three gneisses, Coös slates and calcareous masses, with an argillo-micaceous paste. Some pebbles are a foot long. They are usually slaty but not distorted.

Crossing the river and walking over twenty rods of gravel, we came next to a more interesting locality in the south branch valley. The first ledge, back of the last house on the road, is micaceous slate with calcareous layers, cut by an obscure igneous dike. The strata dip 45°, N. 20° W. Beneath are fifty feet of coarse conglomerate, containing, in addition to the pebbles under the bridge, pieces of the mica schist of the Coös group, without staurolite. The slates next observed have a higher dip. They are followed by indurated slates dipping 50°, N. 10° W. They are traversed by beautiful ribbons of banded trap from half an inch to three inches in width, which jump and curve in a fanciful way.

The next series evidently belong to the Lisbon group, having essentially the same strike and dip with the last mentioned beds. They extend for about twenty-five rods along the

stream. The rock is a gritty hydro-mica schist, so far as seen. Probably this is the place for a hornblende aggregate or chloritic rock, which is seen on the west side of Streeter Pond *in situ*, and in enormous bowlders between North Lisbon and the pond. These hard rocks terminate just as the stream bends and passes through a narrow rocky gorge of clay slates containing staurolite and garnet, dipping 60° N. 17° W. The same dip is manifest higher up. The ledges extend for 25 or 30 rods, after which the rocks are covered with earth for a great distance. The banks are made up of bowlder clay, which is undermined by high freshets, and the road has been torn away so many times that the town authorities have been compelled to discontinue the carriage road, thus necessitating pedestrian explorations in this interesting spot. A slate similar to that just described crops out on the new road from the station to Streeter Pond, about a mile northeasterly. The course is nearly east and west, and the strata are more nearly vertical, but the ledges must be continuous between these points. It is shown also by the presence of enormous blocks of diabase, whose source must be to the north of the slates and not far distant. The map shows the distribution of all the parts of this section. The width of the Helderberg conglomerates is about forty rods, which implies a thickness of at least 500 feet. The clay slates correspond perfectly to portions of the Coös group in the Lyme and Lisbon sections, as well as to the interesting staurolite slate seen at Purple's quarry in Bernardston, Mass., described by Professor Dana.

North Lisbon Helderberg.

The rocks of the North Lisbon terrane have been described in part, but not the most characteristic ones. About 100 rods below D. Richardson's, on the east bank of the river, are white limestones containing fragments of the large crinoids. The limestone occurs on both sides of the river. These localities are southwest from fig. 9, and the limestone may prove to be one or two hundred feet thick. Mr Huntington first found these large crinoids, and we traversed the region together the last day of our stay in this region. Contiguous to the limestone is a dark slate, softer than that on Blueberry Hill, which must belong to the series. The same may be true of thick masses of hornblende rock bordering the Helderberg on the northwest flank.

Other Helderberg Localities.

There is no time to describe other localities of the Helderberg with detail. I have long been satisfied that Dalton Mountain belongs to this series, and we have strong suspicions that some

of it will appear in Lancaster. A specimen obtained from one of the mountains back of the Crawford house seems to hold an obscure crinoid in it. More decided is a locality in East Hanover, where I have found a considerable thickness of slate conglomerate. The locality was visited before the first discovery of the corals of Littleton. I doubt not that scores of new localities of the Helderberg will be discovered along the Connecticut Valley, as explorations progress, since we now know what to look for.

A locality of undoubted Helderberg slates and limestones, the latter very scanty, appears in Lyman, north from the Dodge gold mine, upon a hill near D. Knapp's house. The limestones here contain small crinoidal fragments. The slate is friable, dipping 75° northwesterly, and 800 feet wide. The map shows how far they have been traced continuously to the northward, viz: nearly to Young's Pond. These slates over a part of their area contain veins of white cavernous quartz full of iron rust, which have been explored for gold. I do not think gold is found in them. They can be distinguished from the true gold quartz of this region by the absence of ankerite and the very fetid odor. North of Young's Pond are also irregular Helderberg slates.

A difficult problem has been propounded by our late discoveries, which cannot be solved satisfactorily without further explorations. From the south we carry the auriferous clay slates northeasterly, and from the north we trace the Helderberg series of slates in the reverse direction until they meet the former. They are so much alike that no effort has been made to separate them, and consequently it is impossible to say where one ends and the other begins. The boundary line must lie between Blueberry Hill and Young's Pond.

Swift Water Series.

While occupied in investigating this subject, I found a set of specimens which could not readily be referred to any of the series that have been mentioned. I had supposed them to be connected with the Lisbon group, but a careful examination of the specimens did not tend to confirm this impression. I will present a section of much importance crossing this and other groups, in a northwesterly direction, from Bronson's limestone quarry in Lisbon, through the village, and past the gold mine in Lyman, and nearly past Parker Hill in Lyman. This is the route selected for the measurement of the thickness of the Lisbon, Lyman and clay slate series, referred to above.

At the southeast end of the section, there are ordinary gneisses dipping about N. 20° W., and holding a band of azoic limestone, perhaps 100 feet thick, inclined 50°, which has been extensively quarried by Mr. Bronson. On the hillside

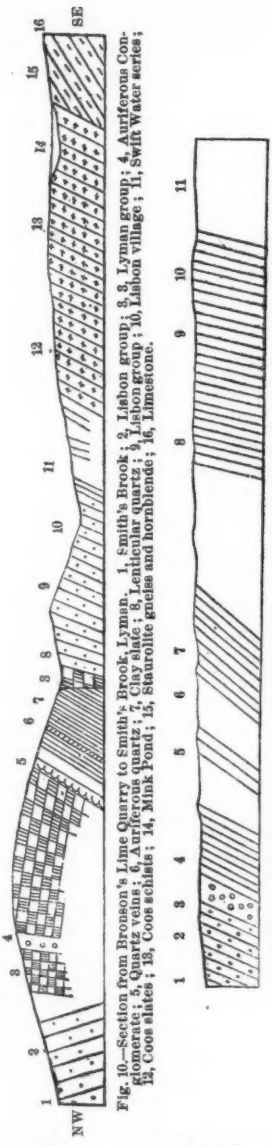

Fig. 10.—Section from Bronson's Lime Quarry to Smith's Brook, Lyman. 1, Smith's Brook; 2, Lisbon group; 3, 3, Lyman group; 4, Auriferous Conglomerate; 5, Quartz veins; 6, Auriferous quartz; 7, Clay slate; 8, Lenticular quartz; 9, Lisbon group; 10, Lisbon village; 11, Swift Water series; 12, Coos slates; 13, Coos schists; 14, Mink Pond; 15, Staurolite gneiss and hornblende; 16, Limestone.

Fig. 11.—Section through Swift Water village. 1, Starch mill. 2, Lisbon group; 3, Micaceous conglomerate; 4, Slate; 5, Gneissic; 6, Mica schist; 7, Swift Water village, Chloritic; 8, Mica schist; 9, Hornblende schist; 10, Micaceous quartzites; 11, Gneiss.

toward the pond are friable gneisses, often very micaceous and carrying simple crystals of staurolite, dipping 30°, N. 60° W. This is bordered by a band of hornblende schist dipping in the same direction; 40° is the average for its whole width. The hornblende is an associate of the gneiss formation rather than of what follows. The estimated thickness of this gneissic group is 2,500 feet. It is not clear to which of the gneissic divisions it belongs, though allied to the White Mountain series in some respects.

Crossing Mink Pond is a gray, friable mica schist holding in profusion the reddish staurolites and garnets, the locality being one well known to mineralogists. The average dip being 56°, the thickness must be 3,300 feet. This band is followed by the same garnetiferous slates which have been described upon the south branch of the Ammonoosuc (fig. 9). Staurolite is less abundant in this than in the previous band, and it is almost wanting in the western portion. With an average dip of 58°, this slate must be over 3,000 feet in thickness.

The Swift Water series follows. For 140 rods there are quartzites and sandstones with an average dip of 50°, which gives 1,769 feet in thickness. More particularly, an excavation for gold at the eastern border shows slaty layers, quite siliceous, with sandstones, considerably vitrified. Next is a sandstone with whitish cement. Then there are in order actinolite schist, hornblende schist, white mica schist, and sand-

stone. For twenty rods beyond, the rock is purely hornblende, and is 300 feet thick. The strata are concealed for 180 rods along the line of section, which must be 2,400 feet thick, if their inclination agrees with those upon both sides. Just beyond is a black slate, exposed at a railroad crossing at the north end of Lisbon village, which is the last member of the series, and has been traced along the strike for eight miles, from near a saw-mill on Wetherbee's Mill Brook in Lisbon to the line of Haverhill. The total thickness of the Swift Water series on this section seems to be over 4,400 feet.

Attention was directed to this group partly by the slate bands and partly by a nondescript conglomerate adjoining it, particularly noticeable a mile and a half north from Lisbon, west of Mr. A. Bishop's, on the northwest side of the river. The pebbles are not discernible till the rock has been weathered nearly white, and even then it is difficult to understand their character. This band is not more than fifty feet thick.

Following up the wild Ammonoosuc River in Bath, there is a characteristic representation of this series of strata, and our name is derived from that of a small village on its banks. The facts given are chiefly from the notes of J. H. Huntington. The Lisbon group seems to extend up this stream for more than a mile above its mouth, judging from its general distribution. A little above a starch-factory, fig. 11, there are strata of micaceous conglomerate of gneissoid aspect, dipping 40° N. 53° W. The slate, or the continuation of the Lisbon band, is half a mile above the factory, and dips 65°, N. 70° W. Less than half a mile above is a more distinctly gneissic band, dipping 56°, N. 50° W. About the village of Swift Water are various exposures of a whitish mica schist, from 40° to 55° dip in the same general direction. There seems in many cases to be feldspar present; certainly a hasty look would make the ledges to be gneiss. On the north side of the river one ledge dips 50°, N. 10° E. There is a band near a cemetery in the southwest outskirts of the village containing crystals of chlorite. Passing above the village the dip rises to 80° and more, or in order, 83°, N. 42° W., and 82°, N. 62° W. The last is the most remote exposure seen. The rocks are micaceous friable quartzites, decomposing so as to appear ferruginous. There are thin, glossy black micaceous bands of a few inches in thickness interstratified with the quartzites. This is at a bridge one and a half miles above the village. A wide band of hornblende schist below the bridge should not be forgotten. The gneiss above has a high dip. It is possible that an anticlinal axis may be indicated by the divergence in the steepness of the dips. There seems to be a prolongation of a spur from the gneiss of Haverhill directly to the point of dip-divergence. There is

considerable lithological similarity between the rocks along the Lisbon and Swift Water sections.

Our general impression of the age of this new series is that it is allied to the Helderberg. The Coös group disappeared finally about two miles below the Lisbon section, so that the Swift Water series lies contiguous to gneiss of a very ancient period for five or six miles. Were the presence of chlorite an index to its age, it would be ranked with the Lisbon group. No one need be disturbed by the apparent dip both of the Coös and Swift Water groups, as well as of the Helderberg strata beneath the Lisbon series; for the lateral force has been exerted so forcibly in New Hampshire, that inversion is the rule rather than the exception. There is no time to present a formal proof of this statement at present.

Conclusions.

Briefly stated, the following conclusions respecting the relations of these Ammonoosuc Helderberg strata seem to be sustained.

1. The fossiliferous limestones belong to the Lower Helderberg.
2. The Helderberg series in New Hampshire is several thousand feet thick, and is composed chiefly of limestones, slates, sandstones, conglomerates and probably hornblende rock. Some of the members are highly metamorphic.
3. These Helderberg strata seem to be newer than the Coös group of the neighborhood, since they contain pebbles derived from the latter series. The lithological character is also different.
4. The Swift Water series seems more nearly related to the Helderberg than any of the other formations.
5. The Helderberg rocks are the newest in this terrane, and the most modern that have yet been discovered in the State.

I propose next to describe the Helderberg strata and associated rocks of Hinsdale, N. H., and Vernon, Vt., as they continue northerly from Bernardston and Northfield, Mass.

ART. LIII.—*On Wheelerite, a new Fossil Resin;* by O. LOEW.

DURING the past season's field-work of the explorations and surveys west of the 100th meridian, under the command of Lieutenant George M. Wheeler, to which expedition I was attached as chemist, many interesting chemical facts were observed. Among these may be mentioned the occurrence of a new fossil resin, whose name heads this article. This resin,

which is yellowish in color, was frequently found in the Cretaceous lignite beds of northern New Mexico, filling the fissures of the lignite, and even interstratified in thin layers with the same. More of this substance was seen in the vicinity of Nacimiento than in any other locality. The strata of lignite, slate and clay, in the numerous sandstone mesas of this region, are plainly to be seen in passing by. The behavior of this resin with reagents and the analysis made proves this to be a new compound, heretofore undescribed.

On treating the resin with alcohol, the principal portion is readily dissolved, while a small part remains insoluble. The hot alcoholic extract of the resin deposits, on cooling, a few yellow flocculi. After the separation of the solution from these flocculi, there remains, after evaporation, a yellowish resin, which is very brittle and becomes strongly electric on friction. This resin melts at 154° C. At a higher temperature it emits an aromatic odor, burns with a smoky flame, and leaves a voluminous coal behind.

It is soluble in ether, less so in bisulphide of carbon. It dissolves readily in concentrated sulphuric acid, producing a dark brown solution. From this solution water precipitates it. It forms a compound with potassa in aqueous solution, and is precipitated by acids unchanged. Strong nitric acid readily oxidizes it, with the evolution of nitrous fumes.

0·106 grm. gave 0·284 carbonic acid and 0·076 water.
0·101 grm. gave 0.270 carbonic acid and 0·071 water.

The data give the formula C_5H_6O.

	Theory.	Experiment.	
		I.	II.
Carbon,	73·11	73·07	72·87
Hydrogen,	7·31	7·95	7·88
Oxygen,	19·58		

The true molecule of the resin is probably 5–6 times larger than the above formula expresses. Many fossil resins have been investigated; but none identical with the above, so far as known, has been described.

The retinic acid of Johnston, which he obtained by extracting the retinasphalt of Bovey with alcohol, is the only combination that bears a resemblance to the substance under discussion. This has the formula $C_{40}H_{45}O_6$; is slightly soluble in alcohol, readily so in ether, and melts at 120° C.

I have taken the liberty of naming this new mineral after Lieutenant George M. Wheeler, Corps of Engineers, U. S. Army, the honored and energetic leader of the expedition to which I am attached.

Laboratory of the Smithsonian Institute, Washington, D. C., March, 1874.

Art. LIV.—*The "Great Conglomerate" on New River, West Virginia;* by Wm. M. Fontaine.

[Concluded from page 465.]

This series, while in some features resembling the overlying Lower Coal rocks, is distinguished by the almost entire absence of shales, notably in connection with the coal beds. We find no well developed under-clays with the coals, and no shales overlying them, features strikingly characteristic of even the lowest bed of the Lower Coal rocks. The seams are enclosed in flaggy sandstones; and all their accompaniments show that they were formed in an era of sudden and violent changes. The beds, followed from outcrop to outcrop, vary much in thickness, showing sometimes, in short distances, a change of several feet. These rapid changes are the only unfavorable characteristic. I could find no specimen of coal sufficiently fresh to give me a good idea of the mineral. Rogers, in his analysis, makes them remarkably free from ash, and with much less bituminous matter than the beds of the Lower Coal series. From the weathered appearance of the bed which I examined in detail, the proportion of sulphur is large, as we might expect from the antiquity of the formation.

The following measurements, kindly furnished me by Mr. Maury, were taken a short distance east of the point examined by myself. They will thus serve as a description of the coal beds at the station. The railroad here runs about 50 ft. above the level of the river.

Distances above the railroad.	
495 ft.	2 ft. seam.
595 ft.	4 ft. "
635 ft.	2½ ft. "
647 ft.	8 in. "
747 ft.	2½ ft. "
847 ft.	1 ft. "
1125 ft., over massive sandstone,	4 ft. 10 in. seam.
1315 ft.	4 ft. 6 in. "

The two highest seams occur in the base of the Lower Coals; and these coals, with their enclosing rocks, must, as stated before, be added to the base of the Paint Creek section, leaving an unknown interval between. The lower of these, the 4 ft. 10 in. bed, lies about 50 ft. above the massive sandstone; hence the top of the rock would stand 1,075 ft. above the railroad. This rock itself in this section is about 150 feet thick.

The third seam is a good example of the fluctuations in thickness of the coals of this system. On the road, near the station, it is only 7 in., probably from a slip. About a mile above the

station, it shows an outcrop of 4½ ft. It was here opened, with the view of shipping coal on an extensive scale; but, on following it into the hill, it pinched out to a few inches, and the work was abandoned, the party next opening the first seam above the Conglomerate. The Conglomerate seam is composed of alternating laminæ of dull black charcoal and brilliant black portions. It is much fractured, and somewhat friable, showing sulphur abundantly in weathering. The junction of the roof with the coaly matter is extremely sharp and well defined. The roof is composed of flaggy sandstone, with many well-preserved impressions of plants. The floor is composed, not of the usual fire-clay, but of a curious conglomerate, consisting of rounded fragments of fine grained grey sandstone, and a very fine gray shale, all cemented by shaly matter colored with coaly matter. The shaly fragments are something like the blue shale mentioned as occurring lower in the series.

The plants found in the roof deposits merit careful exploration. I had a very short time to devote to the collection of them.

Alethopteris Serlii is the most abundant. Both varieties, α and β, occur. Next in abundance is *Neuropteris Dawsoni*, of which I obtained several good specimens and one entire leaf, with fragments showing a peculiar union at the bases of adjoining leaves. It would seem that two adjacent pinnules met at their bases under a very acute angle, when the two midribs were fused into a common rachis, which was broadly winged and seemingly partly clasping in its mode of attachment. Also, more rarely, we find *Sphenopteris obtusiloba*, *Sphenophyllum antiquum* and *Cyclopteris Jacksoni*.

We need not be surprised to find so large a proportion of Devonian plants so close under the lower coals; for, as we shall see, there was probably an uninterrupted land flora in some portion of this region, extending from the Chemung up to this era.

As has been stated, the section at Sewell does not expose the base of the Conglomerate series. Or passing to the east, up stream, the constant northwest dip brings up lower and lower strata, until another heavy white sandstone, much like the topmost ledge, is exposed. This portion of the formation I had no opportunity to examine; and hence I cannot give the precise eastern limit. I think, however, that this last rock may be taken as the base; for it indicates a decided change in the conditions controlling the next lower deposits. These, which appear in succession to the eastward, are heavy-bedded sandstones; but now they assume reddish and brownish colors, and are interstratified with red shales. Some of the sandstones still retain their conglomeritic texture; but none is seen beyond Stretcher's Neck Tunnel, a point some eight or ten miles east of Sew-

ell. These rocks of passage, as we may deem them, are succeeded by the brilliantly colored red shales of the Subcarboniferous formation, which are greatly developed in this region. Rising from under them appears a great limestone formation, which is the base of the Subcarboniferous in Virginia, and which appears in great force around Lewisburg. While it is difficult to fix the eastern limit of the Conglomerate with exactness, owing to the blending of its base with the top of the enormously expanded Subcarboniferous formation, Rogers states that the following is the approximate boundary. In the north of the State, in Hampshire and Hardy Counties, it is in the east Front Ridge of the Alleghany; in Greenbrier and Monroe Counties, in the Greenbrier and Muddy Creek Mountains; and farther south, in the Great Flat Top Mountains.*

In accordance with the above statements, we see that this lowest coal series on New River exhibits a triple structure, with a summit and base of conglomeritic sandstones, and a central portion of more argillaceous rocks, which contains beds of coal. If we compare this arrangement with that shown by the Conglomerate in other portions of the country, we shall find that it is the typical arrangement of this formation, wherever it attains a considerable development. We shall also find that the thickening of the whole formation is mainly due to the expansion of the middle portion, and that the increase in the amount of coal closely follows such expansion. It may not be amiss to give a brief description of the Conglomerate at a few other points, in order to confirm these statements.

At its northwest extremity, near Franklin, Pennsylvania, Prof. Rogers shows that the Conglomerate has nearly thinned out, and has no intervening argillaceous portion. The two bounding sandstones have come in contact. To the southeast, at Broad Top Mountain, it is, according to Lesley, less than 200 ft., still containing the upper and lower arenaceous portions, but now, in accordance with its increased thickness, containing a central argillaceous portion, with a small development of coal.

Near Morgantown, at Laurel Hill, we have the triple arrangement, with an entire thickness, according to Dr. Stevenson, of about 350 ft. Near the center of the formation here, according to a local geologist, occur two beds of coal, the lower 15 in. and the upper 15 inches to 3 feet.

The nature of the formation on New River we have already considered.

Followed to the northeast into the anthracite fields, we find a great expansion, with a corresponding development of the mid-

* The details of the general geology of the country, given in this paper to illustrate the relations of the "conglomerate," are mainly derived from Wm. B. Rogers's Virginia Reports.

dle portion and the accompanying coals. Owing to the great coarseness of the rocks here, the sandstones of the central portions are often true conglomerates. It is in the anthracite region only that the entire thickness of the Conglomerate can compare with that of the rocks on New River. Were it not that almost all of the Lower Coal series has been swept off, where the conglomerate rocks are exposed on this stream, the amount of coal present in the two formations here would not be inferior to that exposed in Pennsylvania; but the greatly increased number of seams would prevent any one from attaining the great thickness of some of the anthracite beds.

In accordance with the comparison just made, it would seem that the Conglomerate expands in two directions. If we select a point at the north of the State, such as Westernport on the Potomac, and trace this system of rocks to the northwest into the Sharon coal field in Pennsylvania, we shall find it thinning out rapidly; but, if we proceed to the northeast into Pennsylvania, or to the southwest in West Virginia, we find a very marked expansion. This diminution to the northwest from the above-mentioned vicinity, and thickening to the northeast and southwest, will be found characterizing some of the formations preceding the Conglomerate. It is a noteworthy fact that, in each case, the expansion to the southwest is attended with an increased formation of coal. Prof. Wm. B. Rogers has already called attention to this fact, in respect to the Subcarboniferous and Catskill. This increase of thickness to the northeast and southwest from a fixed point, commencing in the Devonian period, seems to have continued, with some modifications, into the Lower Barren measures of the Carboniferous period. We have seen that, to the southwest, on the Kanawha, the greatly increased thickness of fragmental rocks in the lower coals is accompanied by a great increase of coal. On the Potomac, in the vicinity selected as our initial point, both the entire thickness of the Lower Coal series and the amount of coal are far less.

Wm. B. Rogers has identified the Pittsburg seam near Westernport, and places it about 600 ft. above the lowest coal bed of the Lower Coal series. This would give at this point a little more than 600 ft. for the Lower Coal series and the Lower Barren measures united. He gives no separate measurements for either; but, from the position in which he finds the coal beds, the greater part of this thickness belongs to the lower coals. This is confirmed by the investigations of H. D. Rogers, at Elk Lick, Pa., where he finds 300 ft. of Lower Coal-measures, and 200 ft. of the Barren measures. This shows a considerable diminution of the latter eastward, for we find them 450 ft. thick at Morgantown; and near Caledonia, on Bennett's Branch, in Pennsylvania, to the northeast they measure 500 ft.

In the Lower Coals at Westernport, Wm. B. Rogers gives four coal beds, averaging in the aggregate about 15 ft. One of these is very insignificant (15 in.), and variable. If now we compare the Lower Coal series at this point with the thickness of the fragmental rocks and coals shown over the conglomeritic portion of the anthracite fields of Pennsylvania, we see that the series has expanded to the northeast no less than to the southwest.

While the above facts indicate that the Lower Barren measures thin out to the east, we do not find that they obey the same law of diminution with the older formations. at least to such an extent as the latter. Still, we find that the increased rate of deposition of sediment to the northeast and southwest of the northern portion of West Virginia is not entirely changed. Selecting Morgantown for our point of comparison, since we have no measurements for places farther east, we find the Lower Barren measures here 450 ft. To the northeast, in Pennsylvania, on Bennett's Branch, we find them 500 ft.; while below Charleston, on the Kanawha, we have, as I have shown, good reason to think them over 500 ft. thick. This comparative uniformity of thickness leads us to think that we have, in these rocks, no longer formations fringing a continental mass, as would seem to be the case with the older formations.

We can, I think, detect, in some of the formations underlying the Great Conglomerate, a similar mode of expansion.

From what has already been said in connection with the eastern limit of the Conglomerate on New River, it would seem that the formation cropping out from under it. the Subcarboniferous, has also in that region a great expansion. This is proved by the measurements of Prof. Rogers. He states that a triple structure marks the formation everywhere in the State. At the top, we find brownish and greenish sandstones, with interstratifications of shales; in the middle, red and green, soft, decomposing shales; at bottom, limestones. Measured on the Potomac, near Westernport, we have, for the whole formation, 918 ft. with 80 ft. of limestone. In Greenbrier County we have, for the entire thickness, 2,132 ft. and 822 ft. of limestone, with hardly any shaly seams. To the northeast in Pennsylvania, we have, in the anthracite region, a thickness of 2,500 to 3,000 ft., almost entirely red shale. As usual, the expansion to the southwest is attended with a great increase of coal. There would seem to have been two eras of coal-making. In the top of Little Sewell Mountain, Rogers found a bed of coal close under the Conglomerate. This seems to be the equivalent of the Sharon coal of Pennsylvania, and if so, indicates a remarkable persistence for this slightly developed series.

Lower down in the sandstones and shales, a much more important formation of coal took place, giving rise in the vicin-

ity of Lewisburg, and west of that town, to a bed of four feet in thickness. Still more developed are these coals in Montgomery County, where we have two beds, the lower 2–3½ ft., and the upper 6–9 feet thick; much of the latter being slate.

The strata of this formation in Pennsylvania thin out rapidly to the northwest, just like the Conglomerate, according to Rogers. A line drawn in that direction, from near Westernport, indicates the direction of diminution.

The next formation beneath, viz: the Catskill, will be found to change in a manner precisely similar to the above-mentioned deposits, but in degree even more striking. The following are the measurements of Wm. B. Rogers for West Virginia

On the Potomac, near Westernport, he finds it 200 feet thick. In this part of the State a thin seam of coal presents itself, but often thins out and is lost. To the southwest, near Lewisburg, it is 800 feet thick, with the coal much more developed, attaining in one place the dimensions of nearly four feet.

This formation to the northeast thickens much more rapidly, being, according to Dana, 2,000 to 3,000 feet in the Catskill Mountains.* To the northwest from the Potomac, it rapidly thins out. About six miles east of the White Sulphur Springs the cuttings for the west approach of Lewis Tunnel disclose a very impure bed of coal, about 12 inches thick, which at the opposite end of the tunnel has degenerated into a black bituminous shale. It is uncertain whether this bed occurs in the Chemung or Catskill. If in the former, it must be near the top, close to the latter formation. The rocks immediately to the west, toward the Alleghany main range, show characteristic Chemung fossils in the float rock on the surface; but in the short examination which I made, to discover the fossils in place, I did not succeed in so doing. These strata are very highly inclined and differ in character from those containing the coal. The latter also dip less steeply, and are apparently unconformable with those lying more to the west.

The slates accompanying this small coal seam contain many beautifully preserved Devonian plants, which confirm the supposition of the Catskill age of the strata. Among the plants here preserved are several species of *Lepidodendron*. *Cyclopteris Jacksoni*, *Noeggerathia obtusa* and *Neuropteris flexuosa* also occur. Of the two latter I saw magnificent specimens; I was much surprised to see so finely marked a specimen of *Neuropteris* at this low horizon. *Cyclopteris valida* is common, also species of *Pinnularia*. Among the *Lepidodendra* is *L. Gaspianum*. I was enabled to collect but few of the plants, and have not yet had an opportunity to study them thoroughly. The locality,

* Prof. Newberry and others consider that the greater portion of this mass is Chemung. This agrees better with the expansion of the coal to the S. W.

however, well deserves a careful examination, although the best specimens have been carried off by mere curiosity-seekers.

It would thus seem that the great expansion of the Conglomerate on New River is not an isolated phenomenon, but that it is the effect of a condition of things which began in much older formations, and continued until a later era. The question is suggested: Does not the successive formation of coal on an extended scale, along the southwest border of the Appalachian coal field, commencing in the Devonian period, point to the existence at this time of a continental mass nearer than the Azoic of Canada?

Morgantown, West Virginia.

ART. LV.—*Contributions from the Sheffield Laboratory of Yale College*, No. XX. *On a Feldspar from Bamle in Norway;* by GEORGE W. HAWES, Ph.B.

ASSOCIATED, at Bamle in Norway, with the fluo-phosphate of magnesia and lime which has been called by v. Kobell Kjerulfine, is found a triclinic feldspar. It occurs massive, with two cleavages at an angle of 94°. Upon the more perfect cleavage surface are very fine striations. Its luster is vitreous; color grayish white; semi-transparent. H.=6. G.=2·67. When heated it phosphoresces with a white light and fuses, at about three, to a translucent glass. It is unacted upon by acids, until boiled for a long time, and then but slightly. When heated in a matrass, the tube is dimmed by moisture. The analyses were made according to the usual methods, and gave

	I.	II.
Silica,	66·04	66·05
Alumina,	20·33	20·41
Ferric oxide,	·29	·28
Lime,	1·29	1·30
Magnesia,	1·11	1·08
Potash,	·21	·21
Soda,	10·01	9·81
Ignition,	·95	·96
	100·23	100·10

Oxygen ratio for R, R, Si, 1 : 2·8 : 10.

This analysis shows the mineral to be near oligoclase, if not identical with that species. Its association and its physical properties are the same as those given by v. Kobell for Tschermakite, recently described as a new species of feldspar.* In the specimens examined, which were from the cabinet of Prof. Brush, the feldspar occurred in quite large fragments, so that it was possible to extract it in a state of purity.

* Ber. Ak. München, Dec., 1873; this Journal, March, 1874.

ART. LVI.—*Notes on some of the Fossils figured in the recently-issued Fifth volume of the Illinois State Geological Report;* by F. B. MEEK.

[Concluded from page 490.]

Edmondia ovata; pl. XXVI, fig. 13.—At the time the figure of this shell and the explanations of the plate were prepared at Springfield, being in doubt in regard to its relations to one of the Nebraska species, of which there were no specimens or other means of comparison at hand, I merely wrote with a pencil, provisionally, opposite its number on the explanations of the plate, the name *Edmondia ovata*, which was also in the same way attached to the specimens. The intention was, at the time, to make thorough comparisons with the Nebraska shell in preparing the text for the press. As this intended revision and preparation of the text was prevented by sickness, however, the merely provisional name was, as in some other cases, printed as originally written.

Since the publication of the report, I find, on comparison, that this shell is so nearly like the Nebraska form I have called *E. subtruncata* (Paleont. E. Nebr., p. 215, pl. II, fig. 7), that it may be only a variety of the same. It is proportionally a little longer, and has its beaks somewhat more distant from the anterior end, which is rather more broadly rounded in outline. It may be a distinct species, but I should have hesitated to name it as such, had I been able to make the comparisons and intended revision before the report went to the press.

Schizodus Rossicus de Verneuil; figs. 17*a–e* and 18*b*, *c*, pl. XXVI.—The shells represented by these figures are so nearly like those referred by Prof. Geinitz, in his work on the Nebraska fossils, to *Schizodus Rossicus*, originally described from the Permian rocks of Russia, that little if any doubt can be entertained in regard to their identity, at least, with the Nebraska specimens. In the Report on the Paleontology of Eastern Nebraska, I referred the Nebraska City shells, with great doubt, to *S. curtus* M. & W., from the upper part of the Coal-measures at Grayville, Illinois; stating that, "without intending to express a positive opinion in regard to the relations of these two forms, I have concluded to refer the Nebraska City specimens, provisionally, to *S. curtus*." I noticed, and stated, that the Nebraska specimens are more compressed than the Illinois species, but could not quite get rid of the impression that this might have resulted from accidental pressure, as the specimens were nearly always found lying on one side or the other, on the surfaces of separated laminæ of argillaceous rock.

In subsequently studying the Illinois Coal-measure fossils, however, I soon found that there is there, even in the lower part of the Coal-series, a slightly variable shell, agreeing well with the Nebraska City species, and yet readily distinguishable by its *constantly* more compressed form, and less prominent beaks, from *S. curtus*. Being, at the time the plates were prepared, undecided what disposition to make of these more compressed forms, I merely wrote, temporarily, the name *S. Rossicus* de Verneuil ?, opposite their number on the explanations of the plate, intending ultimately to study them more carefully, before coming to a final conclusion in regard to their relations. The opportunity to do so, however, was prevented, as elsewhere explained, and the name printed in the explanations of the plate as at first provisionally written.

That these shells are really identical, however, with the Russian Permian species *S. Rossicus*, is, I think, extremely doubtful; though they nearly resemble that species in form; and there is, according to Eichwald, a shell sometimes found, in the Carboniferous rocks of Russia, that he could not distinguish from *S. Rossicus*. Still, in a genus like this, where the species often closely resemble each other, and present few external distinguishing characters, excepting the often variable one of mere form, it is perhaps nearly, if not quite, impossible, in many cases, to determine beyond doubt the exact relations between closely allied forms, until their hinges and interiors can be carefully compared.

While looking over the Illinois collections, I was fortunate enough to find two specimens of the compressed form represented by our figures (see fig. 17*c*, *d*), showing the hinges of both valves very clearly. An examination of these figures will show that this shell presents some rather marked differences in the characters of its hinge, from the typical species of *Schizodus*, as illustrated by Prof. King. That is, it has but two *true* teeth in each valve, instead of three in one and two in the other; while the one corresponding to the deeply bifid or split tooth in the typical *Schizodus* is only a little emarginate. According to Prof. King, however, the teeth of this genus are subject to some variations, while Prof. McCoy, who has carefully studied the hinges of the British typical species of the genus (some of which seem not to have been seen by Prof. King), says that the third tooth is often obsolete, and that the bifid one varies in the distinctness of this character. De Verneuil also describes *S. Rossicus* as having the posterior tooth nearly or quite wanting. From these facts, and the general physiognomy of our American forms, I can see no very satisfactory reasons for separating them from the genus *Schizodus*.

At any rate, whatever importance may be attached to the peculiarities of the hinge we have illustrated, so far as regards the relations of these shells to *Schizodus*, I have no doubt that the little shell from the Kansas Coal-measures, for which Mr. Conrad proposed the generic name *Prisconaia*, in the Am. Jour. Conch., vol. i, 1867, is really congeneric with our specimens. I cannot agree with my friend Mr. Conrad, however, in the opinion that these shells belong to the *Unionidæ* (*Naïades*). On the contrary, their entire combination of characters, no less than their constant association with marine types, seem to me to indicate different family relations. That is, they seem to be directly connected, through the typical *Schizodus*, and the various forms included in the genus *Myophoria*, with the *Trigoniidæ*, as maintained by Prof. King.

Yet, if farther comparisons should show that Mr. Conrad's name must be retained in a subgeneric sense, under *Schizodus*, the name of our species, represented by fig. 14*a*, *b*, *c*, will doubtless have to be written *S.* (*Prisconaia*) *curtus*, as it almost certainly has the same hinge-characters; and I even suspect Mr. Conrad's type, *P. ventricosa*, may be *specifically* identical with it.*

It will be seen, by examining our figure 17*e*, that the surface of these shells, when perfectly preserved, and examined under a strong magnifier, in a favorable light, shows very minute, exceedingly regular and peculiar sculpturing. I am not aware that any such markings have ever been observed on the typical European forms of *Schizodus;* but then it must be remembered that this sculpturing is so *extremely* minute, that it is only preserved on specimens that have been replaced by pyrites, or some other very hard mineral, and not subjected to the slightest abrasion. Indeed, so very minute is it, that it would generally escape observation, unless especially looked for. On calling Mr. Conrad's attention to it, he wrote me that he found it to be beautifully defined on the type of his proposed genus *Prisconaia*.

Solenomya (sp. undt.); pl. XXVII, figs. 1*a*, *b*.—I have long been familiar with this shell among our Coal-measure fossils of the West, but have never been quite able to come to a satisfactory conclusion in regard to its relations to a species figured and described by Prof. Cox, in the third volume of the Ken-

* I cannot agree with Mr. Tate and others, who would substitute a new name *Axinopsis*, or some other, for Prof. King's genus *Schizodus*, merely because the name *Schizodon* had been previously used for genera of Fishes and Mammals. Although *Schizodus* and *Schizodon* are etymologically the same, they are still distinct enough in sound, and to the eye, not to be confounded. It is desirable of course to avoid proposing names so nearly like others already in use; but, when it has been accidentally done, and there is no danger of confounding two such similar names, more harm results from making changes than from allowing both to stand.

tucky Geological Reports. It is certainly always narrower in proportion to its length, and has, at both extremities, different outlines from Prof. Cox's figure; while it also wants the rather distinct undulations shown on the same. If specifically distinct, it may be called *S. (Janeia) trapezoides.*

We have elsewhere stated reasons for believing that Prof. King's name *Janeia* may possibly yet have to be retained for the Carboniferous and Permian species usually referred to *Solenomya* (=*Solemya*), notwithstanding the fact that Prof. King withdrew it at a later date.*

Placunopsis carbonaria M. & W.; pl. XXVII, figs. 2*a*, *b*, *c*, *d*. It is quite probable that this shell may have to take the name *Anomianella carbonaria*, as it seems to agree with a genus published under the name *Anomianella* by Rychholt, in 1852, from the Carboniferous rocks of Belgium. I have not seen a figure or good description of Rychholt's genus; but it is said to be thin, more or less oval, without any perforation in the lower valve, and to grow attached to other shells—all of which characters would appear to indicate very close relations to our species. They are, however, also equally applicable to *Placunopsis*, of Morris and Lycett, proposed in 1853 for Jurassic species. But, even if *Anomianella* and *Placunopsis* are synonymous, the above suggested change would almost certainly still be necessary, *Anomianella* having priority of date over *Placunopsis*.

Anomphalus rotulus M. & W.; pl. XXIX, figs. 10*a*, *b*, *c*.—This is the type of the group for which we proposed the name *Anomphalus*. I merely call attention to it here to correct an error into which I regret to have led Prof. Bradley, in regard to a little Illinois Coal-measure shell referred by him, not long back, to this genus, in this Journal. At the time he showed me his specimens at Washington, I had not seen the original drawings of our type (which were at Springfield, Ill.) for several years; and, from having confounded it, in mind, with another form, I supposed Prof. Bradley's shell to belong to our genus. A moment's comparison with our figures cited above, however, will show that the very broad flattened columella of Prof. Bradley's shell at once places it in an entirely distinct and, as I think, undescribed genus, probably of different family relations.†

Euomphalus rugosus Hall; pl. XXIX, figs. 11*a*, *b*, *c*.—This shell was referred by Prof. Geinitz, in his work on the Nebraska fossils, to the articulate genus *Spirorbis*. I have elsewhere insisted, however, not only that it is specifically and generically distinct from the foreign form with which Prof. Geinitz supposed it to be identical, but that we have a group of larger

* See Proceed. Acad. N. S. Philad., April, 1870, p. 44.

† See page 151 of this volume.—EDS.

species in the Coal-measures of Illinois, which appear to me to connect it so intimately with the genus *Euomphalus* of Sowerby, as to show it to be a true mollusk, if not really a species of Sowerby's genus. By comparing the figures cited above with the forms represented by figures 12*a*, *b*, *c*, 13*a*, *b*, *c* and 14*a*, *b*, *c* of the same plate, this will, I think, be apparent enough to any one.

In conclusion, I would remark, in connection with what has already been said respecting the Coal-measure fossils illustrated in the Illinois Report under consideration, that a comparison of these forms, particularly those represented on pl. XXVI, with those figured by Prof. Geinitz in his "Carbon-formation und Dyas in Nebraska," will, it is believed, clearly show that those Nebraska so-called Dyas rocks cannot be separated from the true Coal-measures upon any well-defined paleontological evidence. I have, however, so fully discussed this subject in the Report on the Paleontology of Eastern Nebraska, that it is unnecessary more than merely to allude to it here.

Pleurotomaria Gurleyi; pl. XXX, figs. *b a*, *b*, *c*.—This species was described by me in the Proceed. Acad. Nat. Sci. Philad., for August, 1871, page 177.

NOTE.—In addition to the typographical errors noted in the list at the end of the volume, the following errata should be corrected:

Page 477, 4th line from top, for "connection," read connections.
" 568, 20th line from bottom, for "γρκμμὰ," read γραμμή.
" 592, 2d line from top, in explanations of pl. XXVIII, and index, for "ventricosus," read ventrica; the latter being the original orthography, as written by N. & P.
" 602, 16th line from top, for "specimens," read species.
Expl. Plate IV, top line, for "Theimei," read Thiemei.
" " XIV, 16th line from top, for "small simple arms," read small simple arm.
" " XX, 4th line from bottom, for page "330," read page 530.
" " XXIX, 10th line from top, for "fig. 5*," read fig. 2*.
Lettering of pl. XXVI, lower left-hand figure, for "21*d*," read 20*d*.

It is perhaps hardly necessary to explain that the references to the Proceed. Acad. N. S., in connection with the remarks on the genera *Actinocrinites*, on page 339, *Batocrinus*, page 364, *Megistocrinus*, page 393, &c., are merely intended to designate where these remarks were first published by us, and not to refer to the original description of those genera.

Jacksonville, Fla., January, 1874.

ART. LVII.—*Contributions from the Sheffield Laboratory of Yale College.* No. XXX.—*On the Chemical Composition of the wood of Acrogens;* by GEORGE W. HAWES, PH.B.

THE following analyses, giving the elemental composition of some dried plants of the class of Acrogens, will be of interest, as showing the relationship between these and other forms of vegetable matter. It was from this class of plants that coal was mostly formed, and the analyses will therefore be of value in calculations as to the origin and formation of coal beds. Some of them have been used by Prof. Dana in the new edition of his Geology in illustration of this subject. With the exception of the stem of the Tree-fern, the plants were collected near New Haven. Average samples of the part above ground were made, including the spores, and including, in the case of *Lycopodium complanatum*, a due proportion of the trailing stem, and in the case of the fern, *Aspidium marginale*, a portion of the woody rhizoma.

The combustions were made with chromate of lead as an oxidant, but for the sake of experiment, the Equisetum and the Lycopodiums were afterward burned with the mixture of potassium dichromate and kaolin, which has been proposed as a substitute by Prof. S. W. Johnson. (See this Journal for May.)

The following were the results obtained: analyses 9 to 12 are of the tree fern, 9 and 10 of a complete section of the stem or trunk, and 11 and 12 of the exterior or "cortical" part.

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Ash.	
1. Lycopodium dendroideum,	47·11	6·39	41·85	1·40	3·25	100
2. " "	47·29	6·43	41·62	1·38	3·28	100
3. Lycopodium complanatum,	45·78	6·25	40·66	1·84	5·47	100
4. " "	45·62	6·26	40·79	1·84	5·49	100
5. Equisetum hyemale,	41·94	5·89	39·23	1·12	11·82	100
6. " "	41·96	6·01	39·21	1·12	11·70	100
7. Aspidium marginale,	44·77	5·99	41·97	2·08	5·19	100
8. " "	44·70	6·05	42·03	2·05	5·17	100
9. Cyathea canaliculata, section,	45·39	6·11	39·82	1·12	7·56	100
10. " "	45·33	6·21	39·76	1·10	7·60	100
11. " " "cortical" part,	48·72	4·89	38·48	1·42	6·49	100
12. " " " "	48·61	4·95	38·53	1·42	6·49	100

Excluding the ash from these analyses, we have the following as the composition of the vegetable tissues. For the sake of comparison, an analysis by Websky of a Sphagnum, the peat plant of swamps and a member of another class of the Cryptogams, is added; and also analyses of three kinds of wood.

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	
Lycopodium dendroideum,	48·79	6·62	43·15	1·44	100
Lycopodium complanatum,	48·35	6·61	43·09	1·95	100
Equisetum hyemale,	47·54	6·74	44·45	1·27	100
Aspidium marginale,	47·18	6·35	44·30	2·17	100
Cyathea canaliculata, section,	49·08	6·66	43·05	1·21	100
" " "cortical" part,	52·04	5·26	41·18	1·52	100
Sphagnum (Websky),	49·88	6·54	42·42	1·16	100
Oak (Payen),	50·00	6·20	43.80		100
Beech "	49·25	6·10	44·65		100
Ebony "	52·85	6·00	41·15		100

From these analyses it is evident that the wood of Acrogens does not differ in ultimate composition from that of ordinary forest trees, since the percentages of the constituent parts all come within the limits of variation, not only of the different kinds, but often of the same kind, of wood. Payen obtained from one specimen of hard oak wood 54·44 of carbon; and Baer from the beech obtained a percentage as low as 46·10. Their microscopic structure would seem to show that they contain about the same amount of cellular tissue.

The stem of the tree fern was brought from Tahiti by Prof. Dana. The central pith, as usual, was gone. For the first two analyses (Nos. 9, 10) a complete section of the stem was made, and sampled. For the other two (Nos. 11, 12) a portion of the outer "cortical" layer was taken. This is composed of a very hard material, much better fitted to resist force and decomposition than the soft wood and pith; and this is the part that is commonly called the bark. But it is evident that in this, as in other endogenous forms of vegetation, there is no true bark.

This cortical portion forms the support of the fronds, which on dropping away leave it as a sheath; but the section of the stem shows that the true wood of the interior is likewise surrounded by this hard substance, nearly as thick, and showing the same microscopic structure and arrangement of layers as the so-called bark. (See plates in Hugo Mohl's Essay on the Structure of the Stem of Tree Ferns, in Martius Icon. Plant. Crypt. Brazil.) Hence, although the exterior is more hard and resisting than the pith, it is not more so than much of the interior of the plant; the portions which are left finally undecomposed can not, therefore, be more correctly called bark than the exterior of the stems of Lycopodiums. Its resemblanee in composition to ebony will be noticed in the table. In the microscopic sections above referred to, small particles of resin were seen lying immediately against these hard portions of the tree fern; and the secretion of oils, camphors, resins, and other bodies rich in carbon, by tropical trees, makes its resemblance to such woods more striking, although it does not differ essentially from some of the oak woods which have been analyzed.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Antimonous chloride as a Test for Cæsium.*—Godeffroy has noticed that a solution of antimonous chloride in concentrated hydrochloric acid gives, in not too dilute solutions of cæsium, a white crystalline precipitate, not soluble in an excess of acid. The other alkali-metals are unaffected by this reagent. The precipitate, collected on a filter, washed with concentrated hydrochloric acid, and dissolved in the same acid, very dilute, yields on evaporation well formed, hard crystals, permanent in the air, and belonging to the hexagonal system. When obtained pure by repeated recrystallizations, analysis afforded chlorine 33·419, antimony 30·531 per cent, corresponding to the formula $SbCl_3CsCl$. It is decomposed by heat and also by treatment with water; though it is readily soluble without change in dilute acids. The author prefers this reaction to that obtained with stannic chloride by Sharples* and also by Stolba, since this produces precipitates with rubidium salts, difficultly soluble in hydrochloric acid, and if ammoniacal salts be present, throws down also the ammonium double salt; whereas both the ammonium and the rubidium double antimonous chlorides are easily soluble in concentrated hydrochloric acid.—*Ber. Berl. Chem. Ges.*, vii, 375, April, 1874.

G. F. B.

2. *On the Production of Black Phosphorus.*—Ritter finds that the black variety of phosphorus, first described by Thenard, and which is produced by the sudden cooling of melted phosphorus, can be uniformly obtained when the phosphorus contains arsenic. The property of becoming black may therefore be readily communicated to phosphorus by placing it for a short time in an arsenical solution, preferably acidified with hydrochloric acid. In thin layers, this form of phosphorus is translucent, and melts on heating to a colorless liquid, which on slow cooling becomes ordinary phosphorus. On treating the black variety with carbon disulphide, the black material is left as a residue, having the composition As_2P. In contact with air it becomes brown, and if preserved in water, the arsenic oxidizes and goes gradually into solution. The quantity of arsenic phosphide which is necessary to produce this blackening of phosphorus is very small, half of one per cent, and in some cases even less, being entirely sufficient. On evaporating the carbon disulphide in a current of carbonic gas, the phosphorus which is left is colorless and does not blacken on sudden cooling. Indeed, the same result may be produced mechanically: a tube constricted at a point a quarter of its length from below, is filled with the arsenical phosphorus and kept in fusion at a temperature of 50° for eight to ten hours. It is then very slowly cooled. On breaking the tube at the narrowed point,

* This Journal, II, xlvii, 178, 1869.

the phosphorus in the upper portion, in which the arsenic phosphide has collected, becomes black on sudden cooling, while that in the lower portion undergoes no such change. The author concludes therefore that black phosphorus is not an allotropic form of this substance, but that the result is due to a sort of liquation produced by the presence of an impurity. In the case of commercial phosphorus, this is generally arsenic; but other substances will effect the result, as is shown by Blondlot's black phosphorus produced by mercury. Ritter has obtained it with copper also.—*Bull. Soc. Ch.*, II, xxi, 151, Feb., 1874. G. F. B.

3. *Influence of the position of the Oxygen atoms in the Molecule upon the boiling point.*—From an extended comparison of metameric organic bodies containing oxygen, NAUMANN derives the following law relating to the influence of the position of the oxygen upon the boiling point: In metameric bodies of the same chemical character and of otherwise similar structure, the more the oxygen—similarly combined in the molecule—approaches the middle of the atomic chain, the lower is the boiling point. Of the numerous examples given, one from each class must suffice for illustration:

		Boiling point.
	Normal Alcohols.	
Normal primary butyl alcohol,	$CH_3.CH_2.CH_2.CH_2$ (OH)	116°
" secondary " "	$CH_3.CH_2.CH(OH).CH_3$	99°
	Isoalcohols.	
Fermentation amyl alcohol,	$(H_3C)_2CH.CH_2.CH_2$ (OH)	128°–132°
Methylpseudopropylcarbinol,	$(H_3C)_2CH.CH(OH).CH_3$	104°–108°
Dimethylethylcarbinol,	$(H_3C)_2C(OH).CH_2.CH_3$	98·5°–102°
	Mixed Normal Ethers.	
Methyl-propyl ether,	$CH_3.CH_2.CH_2.O.CH_3$	49°–52°
Diethyl ether,	$CH_3.CH_2.O.CH_2.CH_3$	35·5°
	Mixed Iso-ethers.	
Methyl-isoamyl ether,	$(H_3C)_2CH.CH_2.CH_2.O.CH_3$	92°
Ethyl-isobutyl ether,	$(H_3C)_2CH.CH_2.O.CH_2.CH_3$	78°–80°

Compound Ethers.

Propyl acetate, $CH_3.C(=O)-O-CH_2.CH_2.CH_3$ 101·98°

Ethyl propionate, $CH_3.CH_2.C(=O)-O-CH_2.CH_3$ 98·8°

If we compare together methyl butyrate, $CH_3.CH_2.CH_2.C(=O)-O-CH_3$, with propyl propionate $CH_3.CH_2.C(=O)-O-CH_2.CH_2.CH_3$, the first of which boils at 102° the last at 122·44°, it would at first seem as if this law was contradicted; since the linking oxygen atom in the latter is exactly in the middle of the chain. But the explanation of this apparent anomaly is found in the fact, readily observed on comparing together butyl propionate $CH_3.CH_2.C(=O)-O-CH_2.CH_2.CH_2CH_3$, and propyl butyrate, $CH_3.CH_2.CH_2.C(=O)-O-CH_2.CH_2.CH_3$, boiling, the one at 145·99°, the other at 143·42°, that for an analogous position of the linking oxygen atom, the influence of the saturating or doubly combined oxygen atom is proportionately greater; so that in the former case moving the saturating oxygen atom from the center of the chain, more than counterbalances the approach toward it of the linking oxygen atom. This result the author explains by the hypothesis that when condensation from the gaseous to the liquid state takes place, similar parts of the various molecules approach more closely in proportion as the oxygen lies nearer the center of the chain.—*Ber. Berl. Chem. Ges.*, vii, 206, March, 1874. G. F. B.

4. *On the Vibration of Liquid Surfaces.*—Barthélemy has subjected to investigation the undulations which are produced upon liquid surfaces when these are thrown into vibration. Instead of producing the motion of the liquid by a sudden blow or an upward movement, as in the case of Faye's experiment, the author made use of a heavy tuning fork for this purpose, the vessel containing the liquid being in contact with it, either directly or through the intervention of the table on which both rested. The best results were obtained, however, when the vessel of liquid was placed upon the resonant case of the tuning fork itself. Similar results were also obtained upon the sounding board of a piano. In this way the surface of the liquid assumed a fixed condition of elevation and depression, the result of uniform vibration over its entire area. The phenomenon may be observed either directly by a small telescope, or better by projection upon a screen. For this purpose, a beam of sunlight is re-

flected upon the liquid surface obliquely; the reflected beam being rendered horizontal by a second mirror and thrown on to a screen, being first brought to a focus by a suitable lens. The image thus obtained is so steady that it may be photographed. In the case of transparent liquids, the incident beam must be much more oblique. Various attempts were made to fix these wave-surfaces, but without success. The best results were obtained by covering the surface of the vibrating mercury with fused stearin. The solidification of the latter afforded a cast of the wave-form. Fusible metal may be thrown into vibration, but its surface is distorted on cooling. The variously shaped vessels employed were either entirely of glass—in which case the walls should be equally thick in all directions—or were made with a wooden base with glass sides cemented together. Rectangular vessels give two sets of brilliant lines parallel to each side, formed by the ridges of the waves. Between these are less luminous lines produced by the hollows. Bright points are formed at the intersections of both. As the movement dies away, the lines parallel to the shorter sides disappear first, leaving those parallel to the longer; though sometimes components of both are left forming zigzags diagonally across the surface. From his experiments Barthélemy deduces the two following laws: 1st, the breadth of the undulations is inversely as the number of vibrations; and 2d, the distance between two lines produced by the same fork is independent of the density of the liquid. The figures given by circular masses of liquid consist of equidistant circular lines intersected by radii equally equidistant; thus giving trapezoidal forms with curvilinear bases. If the fork touches the vessel, a cross of no vibration appears corresponding to the nodal lines of this vessel. As the vibration ceases, two opposite sectors disappear and the two alternate ones remain. By placing sand on the surface of the mercury and then covering it with water, circular lines are formed and also the cross of no vibration; the sand gathering in heaps at the vibrating parts. Triangular vessels give lines perpendicular to the sides, forming brilliant hexagons, the centers of which are the angles of fainter hexagons, having the radii of the first set for sides. As the motion lessens, only one set of lines persists and the surface is covered with rectilinear waves perpendicular to one of the bases. Elliptical vessels give figures of exceeding beauty, the lines having reference to the two axes of the ellipse. The author calls attention to the general character of these wave-surfaces. In the basin of a fountain, in the waves of the sea, these forms are recognized. Even in the sand on the sea bottom they can be traced. Certain lines thus made gave on measurement 2·6 vibrations per second. They may be seen 100 meters from the beach and at a depth of eight or ten meters. So, out of the water, the sand on the beach was found to have taken these forms; thus suggesting that the air itself was capable of similar vibration. So also clouds are arranged often in parallel bands, being then considered a precursor of fine weather. Even in geology, the author thinks certain regular and equidistant

foldings of stratified rocks evidence of analogous vibrations. The ventral segments of a liquid vein, M. Barthélemy thinks, are produced by the vibration of the liquid mass upon which it falls reacting upon it. And he makes an ingenious application of these facts to account for the phenomena of stratification produced by electric discharges in rarefied media.—*Ann. Chim. Phys.*, V, i, 100, Jan., 1874. G. F. B.

5. *Expansion of Gases.*—Ph. Jolly has recently conducted a series of experiments on the expansion of gases, and a new form of air-thermometer. His apparatus consists of a bulb tube containing the gas to be studied, connected by a long rubber tube, containing mercury, with an open cylindrical manometer tube. By varying the height of the latter the pressure may be altered at will. The volume of the gas is always rendered precisely the same by bringing the mercury just in contact with a glass point inside the bulb tube. The observation therefore consists in measuring the pressure at various temperatures. The coefficient of expansion of various gases was thus determined with the following results. The numbers are multiplied by 10^6 or one million, to render a comparison more convenient. The coefficient for air was found, from 20 measurements, to be 3669·6, while Rudberg found it 3645·7, Regnault 3665, and Magnus 3667·8. Hydrogen gave a result 3656·2, nitrogen 3667·7, oxygen 3674·3, carbonic acid 3706·7. The same instrument is also readily employed as an air-thermometer.—*Poggendorff's Jubelband*, p. 82. E. C. P.

6. *Refraction and Dispersion of Gases.*—Mascart has employed for this purpose a spectroscope in which the collimator is placed at a considerable distance from the prism. The parallel beam emerging from the collimator is divided into two by a double plate of the form proposed by Fizeau, and the two equal portions are thus separated several millimeters. They next traverse tubes to contain the gas, closed with plates of glass, and are then brought together by a second double plate turned in the opposite direction from the first, and are finally refracted by the prisms.

If we cause a difference in path of the rays either by varying the pressure of the gas in one of the tubes, or by turning the double plates, a series of dark lines are produced in the spectrum known as Talbot's bands. In any case, calling D the difference in path or retardation, F the number of a particular band and λ its wave-length, we have $D=F\lambda$. Calling n the index of refraction and H the pressure to which the gas is subjected, it is found that we may express the value of n by the equation $n-1=a\,(1+\frac{1}{2}\,B\,H)$, in which a and B are constants. In the same way Regnault's results for pressures under 8 atmospheres show that $\frac{d}{H}=A'(1+B'H)$, so that if the excess of refraction $n-1$ is proportional to the density d of the gas, the two coefficients $\frac{1}{2}\,B$ and B' should be equal.

In the following table are given for various gases the values of B' as determined by Regnault and $\frac{1}{2}\,B$ measured as described above. We may remark that the refraction and compressibility vary alike, in one direction for hydrogen and in the opposite way

for all the other gases. That they are of the same order of magnitude, except for binoxide of nitrogen and carbonic oxide, while in no cases are they exactly equal;

Gas.	$B' \times 10^5$	$\frac{1}{2}B \times 10^5$	$\beta \times 10^5$	$10^3(n-1)$	$C \times 10^4$
Hydrogen	− 57	−87	381	·1388	44
Air	+107	+72	383	·2923	58
Nitrogen	68	85	382	·2972	69
Protoxide nitrogen	754	880	388	·5084	127
Binoxide nitrogen	225	70	367	·2967	
Carbonic oxide	435	89	367	·3336	75
Carbonic acid	901	720	406	·4494	52
Sulphurous acid	3220	2500	471	·6820	
Cyanogen	3220	2700		·8202	100

This difference may be in part due to the difficulty of their determination, to differences of temperature, and to want of exactness of the formulas employed. Hence we may say that at a constant temperature the excess of refraction $n-1$ of a gas is nearly proportional to the density.

The same law does not hold as we change the temperature; if f is the number of bands which pass when the pressure varies from one value to another, $f(1+at)$, instead of being constant, continually diminishes as the temperature rises, so that the usual coefficient α must be replaced by a larger one β, whose value multiplied by 100,000 is given for temperatures below 40° in column four of the above table. In the case of carbonic acid and binoxide of nitrogen β has the same value as α.

To find the absolute index of refraction it is sufficient to measure the length of the tube and to know the value of the wave-length λ. With the soda-flame the index was found to be what is given in column five of the table, that is the index for air $n=1{\cdot}0002923$, the temperature being 0° and the pressure 760 mms.

The same apparatus was employed to measure the dispersion of different gases. The slit of the collimator is illuminated at the same time by the calcium or other white light and by the sparks of an induction coil between metallic conductors. In the spectrum may then be observed at the same time the bright lines of the metals and the bands of Talbot. Making the experiment at different pressures, affords a means of determining the dispersion, or of measuring C in the formula of Cauchy $n-1=A\left(1+\frac{C}{\lambda^2}\right)$. These values multiplied by 10,000 are given in column six of the table.

To show more exactly the order of magnitude of the dispersion of gases compared with that of other well known bodies, the value of the dispersive power $\frac{n'-n}{n-1}$ has been computed between the rays B and H of the solar spectrum. For air the result is ·024, for the ordinary ray in quartz ·032, for water ·040, for crown glass ·038, for protoxide of nitrogen ·053, for heavy flint glass ·69.—*Comptes Rendus*, lxxviii, 617, 679. E. C. P.

7. *Refraction of compressed water.*—MASCART has combined the apparatus described above, with that employed by Jamin, to study interference in compressed water. The two tubes were about two meters in length and the pressure in one was kept constant while it could be varied at will in the other. A change of pressure of one meter caused about 70 bands to pass any given point, so that a variation of one or two mms. was perceptible.

First, he proved that at a constant temperature the ratio of the number of bands passed, to the change of pressure is not proportional to the pressure but increases slightly with it. At 15° for a change of one meter 67·70 passed when the mean pressure was one meter, and 68·52 when it was 3·30 meters. It seems to result from this that the compressibility of water varies more rapidly than the pressure, as has already been observed for other liquids. For a temperature of 5·5° the number of bands was 71·85, corresponding to a change much greater than that resulting from the experiments of M. Grassi. The same effect was obtained whether the pressure was transmitted by a column of water or a mass of air. Assuming the laws of the refractive powers, or that n^2-1 is proportional to the density, the compressibility $\mu=$·0000518. Assuming that $n-1$ is proportional to the density gives $\mu'=$·0000453. The first result is very nearly that obtained by Jamin, but Grassi, by direct experiment, found $\mu=$·0000471, so that neither hypothesis seems to be exact.

The extreme delicacy of this method renders it possible to measure the disengagement of heat produced by the compression of water, or rather the lowering of temperature when the pressure is suddenly removed. One of the tubes being at a great pressure, a stopcock was suddenly opened which allowed a few drops to escape and instantly reduced the pressure to that of the atmosphere. During this time a great number of bands passed, too rapidly to be counted, but this effect ceased suddenly and the bands appeared immovable. On continuing to observe them for some time, they were seen to continue to move slowly in the same direction, owing to the gradual return of the liquid to the temperature of the surrounding medium. At 16° a fall of pressure of 4·38 meters produced in this way a motion of 1·9 bands; hence the index of refraction had diminished ·00000056. From the experiments of Gladstone and Dale it follows that this corresponds to a change in temperature of ·00110°. A computation gives a result ·00109°. The closeness of this agreement is however accidental, as the position of the bands could only be determined to one-tenth.—*Comptes Rendus*, lxxviii, 801. E. C. P.

8. *Maximum of density of water.*—Prof. MACH has determined the temperature at which water reaches its maximum of density to be +3·945°. The method employed was that of Rumford, substituting for thermometers thermo-piles which give more promptly the temperature of the surrounding medium.—*Proc. Acad. Vienna*, *Les Mondes*, 506. E. C. P.

9. *The Gaseous, Liquid and Solid States of Water-substance.*—Prof. J. THOMSON recently communicated to the Royal Society a

paper on the pressure of aqueous vapor from ice and water. Taking into consideration the three states, gaseous, liquid and solid, when any two are present together the pressure and temperature are dependent each on the other, so that when one is given the other is fixed. Representing the pressures by ordinates and temperatures by abscissas, we obtain three curves, which must all cross each other in one point, the freezing point in vacuo, or rather in the presence of no gas but its own vapor. It has commonly been assumed that the curves were tangent to each other at this point, so that the rate of increase of the pressure was the same for ice as for water. By the principles of thermodynamics, however, Sir Wm. Thomson proved that these curves, instead of being tangent, were inclined at an angle forming a salient point directed upward, the rate of increase of the pressure suddenly diminishing when the ice melted and then slowly increasing, the ratio of the inclinations in the two cases being 1·13. The next point was to discuss the observations of Regnault, which was done, employing both his engraved curve and the empirical formulæ, and these also it is claimed render probable the presence of the salient point.—*Nature*, 392.

E. C. P.

II. Geology and Natural History.

1. *Glacial phenomena in Nicaragua.*—Mr. Thomas Belt, in his "Naturalist in Nicaragua," published in London early the present year, describes, as follows, Drift deposits in the valley of the Depilto, one of the head streams of a river (Rio Wanks or the Segovian) that rises among the highest mountains of northern Nicaragua, and reaches the Atlantic near Cape Gracias a Dios.

"Going down the valley of the Depilto the massive beds of quartz and gneiss are soon succeeded by overlying, highly inclined and contorted schists, and, as far as where the road from Ocotal to Totagalpa crosses the river, the exposures of bed rock were invariably these contorted schists, with many small veins of quartz running between the laminæ of the rock. On the banks of the river, from about a mile below Depilto, unstratified beds of gravel are exposed in numerous natural sections. These beds deepen as the river is descended, until at Ocotal they reach a thickness of between two and three hundred feet, and the undulating plain on which Ocotal is built is seen in sections near the river to be composed entirely of them. These unstratified deposits consist mostly of quartz sand, with numerous angular and subangular blocks of quartz and talcose schist. Many of the bowlders are very large, and in some parts great numbers have been accumulated in the bed of the river by the washing away of the smaller stones and sand. Some of these huge boulders were fifteen feet across, the largest of them lying in the bed of the river two miles below Depilto. Most of them were of the Depilto quartz rock and gneiss, and I saw many in the unstratified gravel near Ocotal fully eight miles from their parent rock. Near Ocotal this unstratified formation is nearly

level, excepting where worn into deep gulches by the existing streams. The river has cut through to a depth of over two hundred feet, and there are long precipices of it on both sides, similar to those near streams in the north of England that cut through thick beds of bowlder clay. The evidences of glacial action between Depilto and Ocotal were, with one exception, as clear as in any Welsh or Highland valley. There were the same rounded and smoothed masses of rock, the same moraine-like accumulations of unstratified sand and gravel, the same transported bowlders that could be traced to parent rocks several miles distant."

* * * "The transported boulders, near Ocotal, are about three thousand feet above the sea, those near Libertad about two thousand feet"

Mr. Belt infers, from the facts, that the ice of the Glacial era stretched on uninterruptedly from the northern regions of North America through Central America, and probably over South America. But observers have shown that the glacial phenomena occurring on a grand scale about the higher mountains of California and of the summit region of the Rocky Mountains, within the United States, are those of *local* glaciers, and that there is there no *northern* drift. This being so, it is certain that the facts described by Mr. Bent indicate the existence only of *local* glaciers —those of the mountains of northern Nicaragua. They are still of very great interest, as they give a much more southern limit in North America to the local glaciers of the Glacial era than had been before suspected. J. D. D.

2. *Geological Structure of the Alps.*—In the Geneva Archives des Sciences (Bibliothèque Universelle) for February, M. Charles Lory explains at length his theory in regard to the structure of the central mass of the Alps, which he had before announced in his *Description géologique de Dauphiné*, being led to this exposition of his views because of his having been criticized by Studer.

The great facts in the Alps to be explained are: (1) the vertical, or nearly vertical, divisional planes of the gneiss and granite, with the so-called *fan-structure*; (2) the relative position of the secondary deposits (Triassic or Jurassic) lying unconformably upon the crystalline rocks, more generally horizontal, as in the Chamouni region; and (3) the wedge-like inclosures of these strata in the gneiss so strikingly exhibited in the Bernese Oberland.

According to Studer, the gneiss and granite are properly massive, destitute of stratification, the vertical jointings having been formed subsequent to the Jurassic period, and in some cases to the Eocene. Lory, on the other hand, adopts the view of De Saussure that the crystalline rocks are really metamorphic, and that there is a true stratification of sedimentary origin, although it is not to be understood that the divisional planes are all of this nature, the structure being often equivalent to that observed in the porphyritic and trappean rocks. The gneiss shows the stratification distinctly; the granite much less so—though it often passes into the former by insensible gradations, and thus evinces a common ori-

gin with the gneiss; at the same time, true massive, igneous granites are also to be found.

That the stratification of the gneiss is of very ancient origin is clearly seen in the fact that bowlders of it, with the same structure, are often met with in the conglomerates of the Carboniferous, as well as in the later formations. Further, the position of the anthracite (Carboniferous) beds conformable to the crystalline rocks demonstrates the reality of the stratification of the gneiss.

The course of events, according to M. Lory, was this: After the deposition of the Carboniferous, and before that of the Trias, the whole complex system of rocks was upturned and metamorphosed, the strata being thrown into a generally vertical position; then followed the scanty deposits of the Triassic and Jurassic, and then further mountain-making movements. The older rocks at this time were rigid and unyielding, and could accommodate themselves to the pressure only by fracture and faulting, the movements taking place in the planes of stratification, or along horizontal planes. The secondary strata, on the other hand, were comparatively soft and pliable, and yielded readily to the acting force, bending and folding according to the movements of the solid rock beneath, and mostly without fracture. Thus, while the crystalline rocks were broken and faulted on a grand scale, the more recent strata were sometimes left horizontal, sometimes pressed in between the others so as to seem to be conformable, or shoved over and folded upon themselves in the most intricate manner.

M. Lory describes the relations of the rocks of the Petite Gorge of Mt. Salève as an illustration, on a small scale, of these results produced in the adaptation of an upper flexible formation to the new forms of a rigid one below, which has been dislocated by faults or fracture. Besides applying this principle to the portions of Switzerland specially studied by himself, he says that it will also suffice to explain the extreme irregularities observed in the Bernese Oberland.

On the Italian side of the Alps, zones of the crystalline rocks are found which are still nearly horizontal, and which consequently have suffered the same change of position as the secondary strata by which they are covered. At these localities, for example, at Susa, or Mont Cenis, we find, as we should expect, the same regularity of arch that exists in the Jura Mountains.

The so-called *fan-structure* of Mont Blanc and the St. Gotthard is connected with the original stratification, it having been produced by the enormous lateral pressure, which was greatest below, and hence caused there a convergence of the divisional planes, while above, where the compression was less great, there was a divergence. The effect produced then may well be compared, as the writer suggests, to a sheaf of grain tightly knotted at the center. E. S. D.

3. *Bulletin of the United States Geological and Geographical Survey of the Territories.* Department of the Interior.—Bulletin

No. 2, announced on page 236, has been issued more than a month. After papers by Cope, referred to in that notice, there follows one by L. Lesquereux on *the general characters and relations of the flora of the Dakota Group of the Cretaceous.* The genera represented are *Pterophyllum* (Cycad) doubtful; *Liquidambar*, *Populus*, *Salix*, *Fagus*, *Betula*, *Myrica*, *Quercus*, *Ficus*, *Platanus*, *Laurus*, *Sassafras*, *Cinnamomum*, *Diospyros*, *Laurus*, *Aralia*, *Hedera*, *Magnolia*, *Liriodendron*, *Menispermum*, *Paliurus*, *Rhamnus*, *Juglans* or *Rhus*, *Prunus*, nearly all of which now exist and characterize the North American flora. "Indeed, all the essential arborescent types were there except those which are marked by serrate or doubly serrate leaves, as *Tilia*, *Æsculus*, the serrate *Rosaceæ*, *Hamamelis*, *Fraxinus*, the *Urticinæ*, *Planera*, *Ulmus*, *Celtis*, *Morus*, and the *serrate Betula*, *Alnus*, *Ostrya*, *Carpinus*, *Corylus*, *Carya*, etc." The Dakota species are marked by the leaves being entire and coriaceous, excepting a "peculiar short denticulation with outside turned teeth, as in *Populites Haydenii*, *P. flabellata*, *Platanus Newberryi*, *Querçus Mudgii*. The flora is remarkable for its distinctness from that of the Lignitic beds, and also for the absence of any European species of the same age.

The closing article is an important one by James T. Gardner on the Rocky Mountain ranges in Colorado.

4. *The Geological and Natural History Survey of Minnesota. The Second Annual Report*, for the year 1873; by N. H. Winchell, State Geologist, and S. F. Peckham, State Chemist.—This Report treats at length of the distribution of peat in Minnesota, and of the modes of working it, and also gives many facts on the Cretaceous and other geological formations of the State. It closes with a chapter on the Economical geology of the Minnesota Valley, in which, among the various facts, it is stated that the Lignitic beds of the Cretaceous are likely to afford valuable coal mines.

5. *Skeleton of a Whale in the Quaternary of New Brunswick;* by D. Honeyman. (Communicated.)—A skeleton of *Beluga vermontana?*, found in clay of the Champlain Period, at Jacquet River, Dalhousie, New Brunswick, has been presented to the Provincial Museum, Halifax, N. S., by Henry Townsend, Esq. It was found in a cutting of the International Railway, at a depth of twelve feet six inches, at a distance of 400 yards from the sea and twenty-five feet above the sea level. The clay attached to the vertebræ contains numerous fragments of *Balanus*. Dr. Galpin will describe the fossil in a paper to be read before the Institute of Natural Science.

6. *Note on Prof. Heer's new work on the Fossil Flora of the Arctic;* by L. Lesquereux. (Communicated.)—I have received from Prof. Heer a most interesting pamphlet on the Swedish expeditions for the explorations of the high north. In this paper the celebrated Professor gives first an abridged narration of the progress and casualties of these explorations, and then sums up in a masterly manner the results obtained for vegetable paleontology, as far at least as they were recognized from a preliminary examination of an immense amount of material collected and sent to him.

From the Lower Cretaceous of the northern side of Noursoak Peninsula, and in a bed of black shale overlying the gneiss which forms the essential bulk of the land, he found a flora of sixty-eight species, of which seventeen belong to Conifers, nine to Cycadeæ, thirty-eight to Ferns, three to Equisetaceæ, and only one to the Dicotyledons, this a peculiar kind of Poplar. On the south side of the same peninsula near Alanekerduk, on another formation of grayish black shale, Professor Nordenskiöld, Director of the expedition, discovered a quantity of well preserved vegetable remains at a higher level or in the Upper Cretaceous. The specimens represent sixty-two species, viz: ten Conifers, among them a *Salisburia*, found with leaves and fruits, two Cycadeæ, thirteen species of Ferns, and thirty-four dicotyledonous species, distributed in sixteen families and eighteen genera. Among these he mentions leaves of *Ficus*, *Sassafras*, *Diospyros*, *Magnolia*, *Myrtus*, *Leguminosæ*, and remarks that some of the species are known already from the Quadersandstein of Saxony, Bohemia, Moletin (Moravia).

Only five of these species—three Ferns and two Conifers—are identical with those of the first locality or the Lower Cretaceous. Eight hundred feet above this formation, they still found strata of clay and sandstone filled with a prodigious quantity of remains of fossil plants, which, according to Heer, represent a flora of the lowest Miocene; among them he identifies one hundred and thirty-three species, fifty of which are also found in the Miocene of Europe. This flora is totally different from that of the Cretaceous of the same country, no species being identical. This Tertiary formation is covered, like the whole land, by immense deposits of lava.

7. *Eozoon Canadense, the supposed fossil of the Archæan.*—In the April number of the Annals and Magazine of Natural History, a reply to the article by Mr. Carter, from which, on page 437 of this volume, a few paragraphs are cited, is published by Dr. Carpenter, who states that his specimens, which he would be pleased to show to all interested, fully sustain his view. In the May number, Mr. Carter has a rejoinder, repeating his conclusion, based on his extensive knowledge of living Rhizopods. The latter number contains also a paper by Messrs. King and Rowney, repeating their arguments against the animality of the Eozoon.

8. *Manuel de Minéralogie;* par A. Des Cloizeaux, Membre de l'Institut de France, etc. Tome second. Premier Fasicule. 208 pp. 8vo. Paris, 1874. (Dunod.)—Des Cloizeaux's Mineralogy is made up largely of the results of extended personal investigations, especially in its crystallography, and in the accounts of the optical characters of minerals. It is partly for this reason that twelve years have elapsed since the publication of the first volume of his very valuable work. That volume was occupied with the Silicates. This first part of the second volume, after some additional notes on the Silicates, goes on with the species in the following order: (1) those containing Boron; (2) Carbon, the coals, resins, etc., included, and then the oxalates and carbonates; (3)

TITANIUM, which group is not completed. This new part contains plates LIII to LXVIII inclusive.

9. *System of Mineralogy by James D. Dana.*—The 5th "Subedition" of this work was issued by Wiley & Son, in April, 1874. Each "subedition" (or issue from the stereotype plates) embodies corrections of all errors discovered in the work up to its date of publication. The last, in addition to a number of such emendations, also has the Appendix, by Prof. Brush, bound up with the main volume.

10. *A Revision of the North American Chenopodiaceæ;* by SERENO WATSON. Extracted from Proceedings of the American Academy of Arts and Sciences, vol. ix, pp. 82–126.—The *Chenopodiaceæ*, of comparatively small extent and interest in the Eastern Atlantic United States, increase in number and variety westward, especially in the dry interior portion of the continent, where they form as conspicuous and characteristic a feature of the flora as they do in the corresponding region of Asia, although they are not so very numerous in species. Our lamented chief, Dr. Torrey, made them a favorite study, and described or made notes upon many of our species, but never found time to work them all up systematically. Mr. Watson has lately undertaken this, with much spirit and assiduity; and we have the result in this most conscientious and painstaking monograph, upon the same model as those upon *Lupinus*, *Œnothera*, &c. The species are neatly defined, carefully arranged, and very considerably increased in number. It here appears that we have 17 genera, of which two (*Sarcobatus* and *Grayia*, the Grease-woods of the interior desert-region) are the most peculiar, and 82 species. One of them, *Roubieva*, is not indigenous, but a chance introduction from South America. Of the 16 proper genera, all with indigenous representatives, seven, or nearly half, are common to the Old World, but two in Asia only. Of the 82 species, 8 are introduced (mostly species of *Chenopodium* and *Blitum*); of the 74 indigenous species only 9 are common to the Old World. The natural comparison is with the Flora Rossica, in which 39 genera are admitted and 184 species. Even if we exclude European Russia, there is still a preponderance of *Chenopodiaceæ* in the Old World, especially in Asia. Only two of these (*Teloxys* and *Monolepis*) are peculiar to Asia and America, and (as in the analogous cases) are of limited and closely allied species. Our peculiar genera are *Sarcobatus* (here incorporated without question, or reference to Moquin's exclusion of it), *Aphanisma*, *Cycloloma*, and *Grayia* (with structure newly and better described), each of single species; all but the first with annular embryo. Of *Salsoleæ*, with conical-spiral embryo, which largely preponderate in Asia, we have only a single and maritime *Salsola*, of world-wide distribution, while the Flora Rossica has 24, and ten genera besides. Of the flat-spiral group, besides *Sarcobatus*, we have only *Suæda*, which Mr. Watson has brought up to seven species; while the Flora Rossica counts about thrice the number of genera and species. Our strength is in *Atriplex*, in-

cluding *Obione*. The Flora Rossica describes 20 species. But Mr. Watson, as the result of the first comprehensive study of the materials, has brought the number of our species up to 40. That is, if we exclude the introduced weeds, more than half our *Chenopodiacæ* belong to this genus. Copies of this monograph can be had from the American Naturalist Literary Agency at Salem.

A. G.

11. *Sarracenia variolaris.*—The suggestion in a recent number of this Journal (April, 1874, p. 442), that the pitchers of this species and the way in which insects are caught in them should be carefully scrutinized by those who have this plant within their reach, has already begun to be acted upon. Dr. J. F. Mellichamp, of Bluffton, South Carolina, an excellent observer, has already made some very interesting observations upon this species, which abounds in his neighborhood, and has there, even in the first days of May, developed some of its pitchers. His observations and experiments will no doubt be continued and extended. But it may be well to record at once some results to which his first observations point, as communicated in a private letter,—which are substantially as follows.

The efficiency of the tubular leaves of *S. variolaris* and the presence of the sugary secretion within the rim, as stated by Dr. Macbride, are fully confirmed. The sugary secretion, however, seldom appears until the leaf is pretty well grown. This is also the case in *S. flava*. It bedews the throat all the way round the rim, and extends downward a quarter of an inch or more, sometimes three-quarters of an inch. Dr. Mellichamp also informs us —and this is his most curious discovery—that this sweet secretion is continued externally in a line along the edge of the wing of the pitchers down to the petiole or to the ground, forming a honeyed trail or pathway up which some insects, and especially ants, travel to the more copious feeding-ground above, whence they are precipitated into the well beneath. Ants, as we learn from other sources also, are largely accumulated in these pitchers. As to the supposed intoxicating qualities of this secretion, Dr. Mellichamp was unable to find any evidence of it. On cutting off the summit of the pitchers and exposing them freely to flies in his house, he found that the insects which came to them, and fed upon the sweet matter with avidity, flew away after sipping their fill, to all appearance unharmed. On the other hand, he thinks that the watery liquid in which the insects are drowned and macerated possesses anæsthetic properties; that house-flies, after brief immersion in it, and when permitted to walk about in a thin layer of it, "were invariably killed—as at first supposed—or at any rate stupified or paralyzed in from half a minute to three or five minutes," but most of them would revive very gradually in the course of an hour or so. It is important to repeat and scrutinize these experiments.

A. G.

12. Joshua Hoopes, the last survivor of the old school of the Botanists of Chester County, Penn., of which Darlington was

the chief, and the Flora Cestrica the memorial, died on the 11th of May, at the age of 86 years.

13. *Tube-building Amphipoda;* by S. I. Smith.—In examining recently an alcoholic specimen of a species of *Xenoclea*, I noticed a peculiar opaque glandular structure filling a large portion of the third and fourth pairs of thoracic legs, which in most, if not all, the non-tube-building Amphipoda are wholly occupied by muscles. A further examination shows that the terminal segment (dactylus) in these legs is not acute and claw-like, but truncated at the tip and apparently tubular. In this species, a large cylindrical portion of the gland lies along each side of the long basal segment, and these two portions uniting at the distal end pass through the ischial and along the posterior side of the meral and carpal segments and doubtless connect with the tubular dactylus. There can be no doubt that these are the glands which secrete the cement with which the tubes are built, and that these two pairs of legs are specialized for that purpose.

A hasty examination revealed a similar structure of the corresponding legs in *Amphithoe maculata*, *Ptilocheirus pinguis*, *Cerapus rubricornis*, *Byblis Gaimardi*, and a species of *Ampelisca*. In all these except the last two a very large proportion of the gland is in the basal segment. In the *Amphithoe* this segment is thickened and the gland is in the middle. In the *Cerapus* it is very broad and almost entirely filled by the gland, with only very slender muscles through the middle, and the orifice in the dactylus is not at the very tip but sub-terminal on the posterior side. In the *Ptilocheirus* the gland forms three longitudinal masses in the basal segment and is also largely developed in the meral and carpal segments. The dactylus is long and slender and the orifice sub-terminal. In *Ampelisca* and *Byblis* (which, like *Haploöps*, are tube-building genera) the meral segments of the specialized legs are nearly as large as the basal and contain a proportionally large part of the gland. In these genera the remarkable elongation of the two distal segments in the third and fourth pairs of legs is perhaps a special adaptation to enable them to reach back over the deep epimera.

The examination of fresh specimens will doubtless show these structures much more fully.

14. *On a New Genus of Asellidæ;* by Oscar Harger.—The presence of mandibular palpi has been hitherto regarded as a character of the family of *Asellidæ*, and is thus given by Dana (U. S. Exploring Expedition, Crustacea, p. 714), and by Bate and Westwood, in their late work on British Sessile-eyed Crustacea, vol. ii, p. 313. This organ is present and well developed in *Jæra copiosa*, *Asellodes alta*, and *Limnoria lignorum*, marine species of this family found on the coast of New England. It has been carefully figured by G. O. Sars (Hist. Nat. des Crustacés d'eau Douce de Norvège, 1e livr. pl. viii) for *Asellus aquaticus* and occurs in *A. communis* Say as well developed as in the European species, but in *A. tenax* Smith, from Lake Superior, it is wanting. This

species seems to be in all other respects closely related to the genus *Asellus*, differing from other species of that genus by characters of specific value only. The most noticeable of these differences are the following: the antennulæ have the third segment of the peduncle small, short and similar to those of the flagellum; the ocelli are numerous as in *A. communis;* the appendages of the first abdominal segment in the females are subquadrant-shaped, meeting each other along the median line, much as in *A. communis*, instead of subcircular and overlapping as in *A. aquaticus*. The caudal stylets resemble those of *A. aquaticus*, as do also the feet and the mouth parts, except in the absence of the mandibular palpi, and on this character I propose for the species the new generic name of *Asellopsis.*— *Communicated by the Author.*

15. *Floridan Bryozoa, collected by Count L. F. de Pourtales*, described by F. A. Smitt. Part I, 20 pp. 4to, with 5 plates. Part II, 84 pp. 4to, with 13 plates. Transactions of the Royal Swedish Academy, Stockholm, 1873.—Mr. Smitt has no superior in the department of the Bryozoa. He describes with fullness a large number of species, and presents enlarged figures of them in the plates. After giving a table of the depths at which the species occur in Florida seas, and their distribution also in other seas, he observes that the deeper waters contain either very old species, or those having a wide geographical distribution and especially Arctic or Antarctic relations. A few of these Bryozoa are identical with Cretaceous species and a larger number with Tertiary.

16. *Report upon the Invertebrate Animals of Vineyard Sound and adjacent waters, with an account of the Physical Features of the region;* by A. E. Verrill and S. I. Smith. 8vo, 478 pp. and 38 plates.—This work is extracted from the report of the U. S. Fish Commission, noticed beyond, with separate paging. It is accompanied by a special index and table of contents, and includes the following papers: A, Habits and distribution of the invertebrate animals of southern New England and New York, with special reference to their stations, mode of occurrence, as depending upon the temperature and composition of the water, character of the bottoms and shores, etc.; B, Food of fishes, or lists of species found in the stomachs of various fishes; C, Habits and metamorphoses of the lobster and other crustaceans (by S. I. Smith); D, Systematic catalogue of the invertebrates of southern New England and adjacent waters, with their synonomy, geographical and geological distribution, and descriptions of numerous new species. The total number of species enumerated is about 725, (not including the free Entomostraca, Infusoria and Foraminifera). Detailed accounts are given of those species which are directly injurious or beneficial to man, such as the oyster, clams, *Teredos* or "ship-worms," "drills," star-fishes, lobsters, crabs, etc. The 38 plates include about 300 figures, illustrating many of the more important species belonging to nearly every class. This work will be indispensable to every person engaged in studying or collecting the marine animals of our coast, and will afford great assistance to the numerous students who visit the sea-shore in summer.

17. *Field Ornithology, comprising a manual for procuring, preparing, and preserving birds, and a check-list of North American birds;* by Dr. ELLIOTT COUES, U. S. A. Salem, Mass., Naturalists' Agency, 1874.—The scope of this work is clearly indicated by the title. It contains a large amount of useful information for those engaged in the study of ornithology. The directions are very full and clearly expressed, and the advice in regard to a great variety of matters connected with the subject of bird-collecting is sensible, and will prove of great value to those beginning the study. The reputation of the author as one of our most accomplished ornithologists is a sufficient guaranty for the excellence and reliability of the work. The check-list of birds is brought down to the latest discoveries in American ornithology. V.

III. ASTRONOMY.

1. *New Comets.*—Two new comets have been discovered this year, besides that by Winnecke, Feb. 20th (this Journal, p. 446), viz: one by Winnecke, April 11th, and one by Coggia, April 17th.

2. *Inclinations of the orbits of periodic comets.*—In connection with the important observations by Prof. Wright, in the last number of this Journal, upon the polarization of the Zodiacal Light, and his deductions therefrom, the question naturally arises whether there is any constant action of the perturbing forces of the planets tending to draw the meteoroids into orbits of small inclination to the plane of the solar system. The fact that the orbits of most of the periodic comets have a small inclination (counting from 0° to 180°) is sufficiently striking to stimulate inquiry in this direction. The additional fact that several of these orbits are now inclined at a smaller angle to the ecliptic than when first discovered, and that none have essentially larger inclinations, also suggests the possibility of some such law of action. I have not been able, however, in a partial examination of the subject, to detect in the perturbing function, any evidence of such constant forces. H. A. N.

3. *Cordoba Observatory.*—We have received a letter from Dr. Sellack of Cordoba, replying to Dr. B. A. Gould's letter, published in this Journal, vol. vi, p. 399; it is endorsed by five of the professors of the University. We do not publish it, since, whatever may be said of some points connected with the subject, Dr. Sellack violated the law and usage of all observatories in publishing results obtained while under the employ of the Observatory, without the knowledge or approval of its Director.—EDS.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *National Academy of Sciences.*—The following is a list of the papers presented to the Academy at its session in April, 1874.

On the classification of the Rynchophorous series of Coleoptera; J. L. LeConte.

Results of a series of experiments on the sets, or residual deflections of pine sticks after having been subjected to a transverse stress; W. A. Norton.

Combinations of Mechanism imitating mental processes; Fairman Rogers.

On the Tides of Tahiti; Wm. Ferrell.

On the Laws of Cyclones; Wm. Ferrell.

On the pretended localization of the mental and the sensorial faculties of the brain; C. E. Brown-Sequard.

Biographical Memoir of Henry James Clark; A. S. Packard, Jr.

Suggestions as to the functions of Spiral Scalæ of the Cochlea, leading to an hypothesis of the mechanism of audition; A. M. Mayer.

The law of the duration of the residual sonorous sensation; A. M. Mayer.

Experiments on the reflection of Sound from flames and heated gases; A. M. Mayer.

The progress made in the Survey of the Colorado River of the west and its tributaries, by parties under the direction of the Secretary of the Smithsonian Institution; J. W. Powell.

An outline of the history and operations of the U. S. Geological Survey of the Territories, with some account of its results; F. V. Hayden.

The geographical distribution of the Lignitic group of the northwest, with some remarks in regard to its age; F. V. Hayden.

Mineralogical notes; B. Silliman.

The history of Smith Sound in a geographical and geological point of view, and some other general results of the Polaris Expedition; E. Bessels.

On metamerism in inorganic chemistry; Wolcott Gibbs.

On the Polarization of the Zodiacal Light; A. W. Wright.

Account of the proceedings of the Commission for observing the Transit of Venus; A. Newcomb.

On some points in Mallet's theory of Vulcanicity; E. W. Hilgard.

Report on the Great Telescope of the U. S. N. Observatory; S. Newcomb.

Some results of an examination of the U. S. Weather Maps for the years 1872 and '73; E. Loomis.

On a small correction of the Velocity of Light, as deduced from experiments; S. Alexander.

On certain phenomena sometimes presented by three of the Satellites of Jupiter; S. Alexander.

On the Zodiacal Light; S. Alexander.

Biographical Memoir of James H. Coffin; A. Guyot.

On the so-called land-plants of the Lower Silurian of Ohio; J. S. Newberry.

A criticism on the contractional hypothesis of the earth's surface changes; C. Dutton.

A new set of Bernouilli's Numbers; James D. Warner.

2. *American Association for the Advancement of Science.*—The Twenty-third meeting of the Association will be held at Hartford, Connecticut, commencing at 10 o'clock, A. M., on Wednesday, the 12th day of August, 1874. Dr. L. LeConte is the President of the year, Prof. C. S. Lyman, Vice President, Mr. F. W. Putnam of Salem, Mass., Permanent Secretary. The headquarters of the Association will be at the State House, where members will report immediately on arrival.

At an early date, the Local Committee will issue their circular to members of the Association, giving details relating to the arrangements made for the accommodation of members while in Hartford, and such other information as may be of interest to those intending to be present at the meeting, including any facilities offered by the railroads, etc.

In order to receive the circular of the Local Committee without fail, it is desired that all members now planning to attend the meeting should send their addresses to Rev. W. L. Gage, Secretary of the Local Committee, Hartford, Ct.

Members must furnish the Permanent Secretary with complete titles of all the papers they propose to present during the meeting,

with an estimate of the time required for reading each paper. Each title must be given on a separate slip of paper, with the full name of the author. The titles must be furnished to the Permanent Secretary, when practicable, before the day appointed for the Association to convene.

The volumes of the Proceedings of the Association (22 in number) can be obtained from the Permanent Secretary, at the price of $1.50 a volume; any member wishing for ten or more volumes, in order to complete a set, may obtain them at $1.00 a volume.

3. *The Constants of Nature—Smithsonian Miscellaneous Contributions* (255). *Part I, Specific Gravities; Boiling and Melting points; and Chemical formulæ.* Compiled by FRANK WIGGLESWORTH CLARKE, S. B. 203 pp. 8vo. Washington: Smithsonian Institution.—Whoever has the patience and assiduity to compile in a careful and systematic manner such data as form the staple of this volume of "Constants," performs a service for which he merits and will receive the sincere thanks of all who find occasion to use the result of his labors. Prof. Clarke introduces his work with a list of the more important of the papers used in compiling these tables, to the number of 86 titles. The number of distinct bodies, the constants of which are given in the tables, is 2572, and there are over 5000 determinations of specific gravity, and more than 2000 determinations of the boiling point. The substances cited are classified in a sufficiently systematic manner, under 61 separate heads, and references are further facilitated by a copious alphabetical index, covering 23 closely printed pages in triple columns. Prof. Henry, as Secretary of the Smithsonian, has lately issued a circular calling on investigators and observers to send in any data of their own determinations of similar constants, with a view to the compilation of similar works in other departments of physical research. B. S.

4. *Fifth Annual Report of the State Board of Health of Massachusetts.* 550 pp. 8vo. Boston, 1874.—This Report contains, among others, a valuable paper by Prof. W. R. Nichols on the present condition of certain rivers of Massachusetts, together with considerations touching the water-supply of towns. This elaborate paper contains the results of over 450 chemical analyses, made daily upon the chief rivers and lakes, and on sources of water-supply in eastern Massachusetts, which present the ammonia, "albuminoid ammonia," inorganic and organic or volatile solid constituents, both from the unfiltered and the filtered waters, the chlorine and in some cases the lime, magnesia, silica, sulphuric acid, etc. It is noteworthy that the bulk of this analytical work was performed by a lady, Miss Ellen H. Swallow, A. M., in the laboratory of the Massachusetts Institute of Technology, where Prof. Nichols is in charge. The questions of contamination by sewage and the work of manufactures, dilution, filtration, etc., are all carefully considered from experimental data. Another paper of chemical as well as hygienic interest is that on "The use of zinked or galvanized iron, for the storage and conveyance of drinking water,"

by Dr. W. W. Rodman of Boston, whose researches sustain the conclusion that the small amount of zinc, dissolved in drinking water, passing through zinked pipes, is without injury to health, which is much more than can be truly said of lead. The hygienic and sanitary papers in this volume, under the editorship of Dr. George Derby, are of permanent value. B. S.

5. *Report on the Condition of the Sea Fisheries on the South Coast of New England in* 1871 *and* 1872; by SPENCER F. BAIRD, Commissioner. With supplementary papers. Washington, 1873–4. 8vo, 899 pages, with 38 plates and 3 maps.—This is the first volume published by the U. S. Commission of Fish and Fisheries. It contains a report of the Commissioner concerning the general character and progress of the investigations, with a summary of results and discussions of the condition of the fisheries; a large amount of testimony taken in 1871 and 1872 in reference to the present and past condition of the fisheries; reports of various State Commissioners; arguments for and against protective laws; and various other interesting papers relating to the fisheries of America and Europe; statistics of the fisheries of southern New England; natural history of some of the most important food-fishes, including the blue-fish and scup; description of the apparatus used in capturing fish on the sea-coast and lakes of the United States, with a list of the U. S. patents granted for the invention of apparatus used in the fisheries; catalogue of the marine Algæ of southern New England, by Dr. W. G. Farlow; report upon the invertebrate animals of Vineyard Sound and adjacent waters, with an account of the physical characters of the region, etc., by Prof. A. E. Verrill, with accompanying papers on Crustacea, by Mr. S. I. Smith; catalogue of the fishes of the east coast of North America, by Prof. Theodore Gill; list of fishes collected at Wood's Hole, by Prof. S. F. Baird; and a table of the temperatures of the water at Wood's Hole during the year 1873.

From this condensed summary of the contents, some idea may be obtained of the great amount and variety of the information brought together in this volume, which will mark a new era in the history of our fisheries, if not in the general study of our marine zoölogy. Although most of this volume was printed early in 1873, it was not generally distributed until April, 1874. It is furnished with copious indexes and tables of contents, and is illustrated by over 300 figures.

6. *Centennial of Chemistry*, 1774–1874.—A proposition has been made by Dr. H. Carrington Bolton, in a letter in the "American Chemist" for April, that American chemists should meet on the 1st of August, 1874, at some pleasant watering-place, to make special recognition of the year 1774, rendered memorable by so many important discoveries in chemical science, and especially by the discovery of oxygen by Priestley, on the first day of August, 1774. Such a reunion as that proposed would offer many pleasant features of attraction, and an opportunity to discuss interesting chemical topics, and review the wonderful progress made in the past century.

Dr. Bolton's proposition is approved by the Editor of the American Chemist (N. Y.), who invites from others an expression of their views, that the project may be at once put into a practical form in time for the season proposed. Why not make this chemical reunion a prominent feature of the August meeting of the Association for the Advancement of Science at Hartford? B. S.

7. *Observations on the Genus Unio, etc.*, by ISAAC LEA, LL.D. Vol. XIII.—Dr. Lea has here added another volume to his large work on the Unionidæ. It is illustrated by 22 beautiful lithographic plates representing the species described. The volume consists of two papers read before the Academy of Natural Sciences of Philadelphia; one, on fifty-two species of Unionidæ, read in September, 1873; the second, a Supplement, on fifteen species, read February, 1874.

Dr. Lea has also issued recently a pamphlet of 24 pages, containing papers from the Proceedings of the same Academy, read during the five years past, five of them on new species of Unionidæ, one on species of several genera of freshwater shells, and two on microscopic crystals in some minerals. These two last are illustrated by a plate. The minerals examined were garnets, asteriated sapphire, labradorite, a black feldspar, barite, amethyst, ruby.

8. *Hartt on the Geology and Physical Geography of the Lower Amazons.* (Bull. Buffalo Soc. Nat. Sci., No. 4, vol. i.)—Professor Hartt's paper gives new information on the features and geology of the Lower Amazons. In the Ereré district he obtained various Devonian fossils, and determined the beds of the great plain north of the Serra of Ereré, to be of Devonian age. The fossils, according to R. Rathbun, who made careful comparisons with Professor Hall's specimens at Albany, include *Rhynchonella dotis?* Hall, *Tropidoleptus carinatus* Conrad, *Vitulina pustulosa* Hall, *Discina Lodensis* Hall, *Lingula spatulata* Hall, besides new species of *Spirifer*, *Terebratula*, *Retzia*, *Rhynchonella*, *Streptorhynchus*, *Chonetes*, and *Lingula*. Part of the species are identical with New York Hamilton fossils.

9. *On Ocean Currents.*—Professor JAMES CROLL, of the Geological Survey of Scotland, has published Part III of his series of papers on Ocean Currents in the Philosophical Magazine for February. It treats of the Physical Cause of Ocean Currents.

10. *Annual Report of the Trustees of the Museum of Comparative Zoology at Harvard College in Cambridge, together with the Report of the Committee of the Museum for* 1873. 30 pp. 8vo. Boston. 1874.—In an Appendix to these Reports, it is stated that the sums subscribed for the Museum, in addition to the regular income, in 1872 and 1873, amount to $175,909.61, and that, of this sum, about $18,000 were given by Alexander Agassiz for publications, etc., $16,252 by Alexander Agassiz and Quincey A. Shaw, and $100,000 by Quincey A. Shaw. Of the remainder, $5,000 were subscribed by Mrs. G. H. Shaw, $2,000 by Mr. M. Brimmer, $4,060 by former pupils of Prof. Agassiz's Young Ladies' School, $5,500 by a "friend," and $25,000 was a grant

from the State, conditional on the same amount being raised by the Museum.

11. *Bulletin of the Minnesota Academy of Natural Sciences*, for 1874. Minneapolis, 1874. (Price 50 cents.)—Among the articles in this Bulletin, there are: a Report on the Birds of Minnesota, by P. L. Hatch, M.D.; List of the Mammals of Minnesota, by A. E. Ames, M.D.; and Geological Notes from early explorers in the Minnesota Valley, by N. H. Winchell, an important paper containing facts bearing on the distribution of the Archæan in that region.

12. *Errata to papers in this volume by Professor Verrill:*

Page 39, line 45, for *Ophiocnida hispida*, read *Ophiacantha spinulosa*. Page 138, last line, for *Urosalphinx*, read *Urosalpinx*. Page 413, next to last line, for *Phakerellia*, read *Phakellia*.

OBITUARY.

Professor JOHN PHILLIPS, Professor of Geology in the University of Oxford, and eminent for his labors and works connected with his favorite science, died on the 24th of April.

The death of Mr. Phillips was the result of an accident. On the 23d of April he had been dining at All Soul's College, and was returning, accompanied by the Principal of Jesus College, when, in crossing the top of a staircase, his foot unhappily slipped and he fell headlong down a flight of stone stairs. Paralysis and unconsciousness came on instantly, and about one o'clock on the 24th he expired. He was just seventy-three years of age.

Left an orphan at eight years old to the care of his uncle, William Smith, well known as "the father of English Geology," he was as one may say "to the hammer born." His connection with the Yorkshire Philosophical Society dates back to 1826, and with the British Association from its establishment in 1831; indeed, "he was the life and soul of its annual reunions."—*Geol. Mag. for May.*

JOHANN HEINRICH VON MÄDLER, the astronomer, and author, with Beer, of "Der Mond" and the accompanying "Mappa Selenographica," died at Hanover on the 14th of March, having been born at Berlin on the 29th of May, 1794. In 1840 he became Professor of Astronomy at the University of Dorpat, and Director of the Observatory, as successor to W. Struve.

Mineralogisches Lexicon für das Königreich Sachsen, von August Frenzel. 380 pp. 12mo. Leipzig, 1874. (W. Engelmann.)—Saxony is a land of mines and minerals, and this little volume is a convenient work on its mineralogy.

Report on the Department of Mines of Nova Scotia for the year 1873. 88 pp. 8vo. Halifax, N. S., 1874.

Annual Report upon the Survey of the Northern and Northwestern Lakes, in charge of C. B. Comstock, Major of Engineers, U. S. A., being Appendix BB. of the Annual Report of the Chief of Engineers for 1873.

Palæontologica Indica.—Series viii, 3, 4, 5, Cretaceous Fauna of Southern India, Vol. iv, 3, contains the Echinodermata, by F. Stoliczka; Vol. iv, 4, contains the Corals or Anthozoa, with notes on the Sponges, Foraminifera, Anthozoa, by F. Stoliczka. Series ix, 1, Jurassic Fauna of Kutch, Vol. i, 1, contains the Cephalopoda (Belemnitidæ and Nautilidæ), by William Waagen.

There have also appeared the *Memoirs of the Geological Survey of India*, Vol. x, part 1, containing the Geology of Madras, by R. B. Foote, and of the Satpura Coal Basin, by H. B. Medlicott; also the *Records*, Vol. vi, parts 1, 2, 3, and 4.

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